UNIV. OF
TORONTO
LIBRARY

Digitized by the Internet Archive
in 2010 with funding from
University of Toronto

http://www.archive.org/details/lightlighting06illu

Light and lighting

I

JAN. to DEC., 1913.

The ILLUMINATING ENGINEER

ELECTRICITY · ACETYLENE · OIL · GAS

Edited by LEON GASTER

10/6 Yearly. THE JOURNAL OF SCIENTIFIC ILLUMINATION. 1/- a Copy.

OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London 1909.)

VOL. VI.

JAN. 1913 TO DEC. 1913.

133542
27/7/14

ILLUMINATING ENGINEERING PUBLISHING COMPANY, LTD.,
32, VICTORIA STREET, LONDON, S.W.
(TEL. NO. VICTORIA 5215.)

AUTHORS' INDEX.

A — PAGE

Abady, J. Specification of Street Lighting (Discussion) 320
Allen, E. Annual Dinner (I.E.S.) 158
Specification of Street Lighting (Discussion) 316

B

Bailey, F. Modern Methods of Indirect Lighting (Discussion) 39
Shades and Reflectors (Discussion) 148
Annual Dinner (I.E.S.) .. 155
Specification of Street Lighting (Discussion) 315
Baker, C. A. Modern Methods of Indirect Lighting (Discussion) .. 40
Bell, Dr. L. Specification of Street Lighting (Discussion) 275
Blatchley, C. P. Petrol Air Gas Lighting (Discussion) 92
Bloch, Dr. L. Specification of Street Lighting (Discussion) .. 272
Blok, A. Shades and Reflectors (Discussion) 147
Reflectors and Globes, Notes on 420
Correspondence 638
Bohle, H. Interior Illumination, Notes on 411
Bradley, J. W. D. Specification of Street Lighting (Discussion) .. 313
Brewer, R. W. A. Petrol Air Gas Lighting (Discussion) 91
Bunte, Dr. K. The Measurement of Illumination in Streets 5
Butterfield, W. J. A. Acetylene Lighting (Discussion) .. 89
Petrol Air Gas Lighting (Discussion) 90

C

Campbell, C. Modern Methods of Indirect Lighting (Discussion) 46
Use of Shades and Reflectors (Discussion) 150

PAGE

Clark, J. G. Modern Methods of Indirect Lighting (Discussion) 42
Specification of Street Lighting (Discussion) 266, 328
Clark, J. G., and V. H. Mackinney. Notes on the Use of Shades and Reflectors 125
Notes on the Use of Shades and Reflectors (Discussion) .. 152
Clinton, W. C. Modern Methods of Indirect Lighting (Discussion) 40
Use of Shades and Reflectors (Discussion) 152
Cohen, A. E. Petrol Air Gas Lighting (Discussion) 96
Cooper, W. R. Specification of Street Lighting (Discussion) .. 318
Cunnington, A. Shades and Reflectors (Discussion) 151

D

Darch, J. Modern Methods of Indirect Lighting (Discussion) 47
Petrol Air Gas Lighting (Discussion) 95
Use of Shades and Reflectors (Discussion) 145
Specification of Street Lighting (Discussion) 270, 315
Donnithorne. Petrol Air Gas Lighting (Discussion) 91
Dow, J. S. Petrol Air Gas Lighting (Discussion) 97
Specification of Street Lighting (Discussion) 329
Dow, J. S., and V. H. Mackinney. Shadows by Natural and Artificial Light 613
Shadows by Natural and Artificial Light (Discussion) .. 634
Duddell, W. Annual Dinner (I.E.S.) 158

E

Edgcumbe, K. Specification of Street Lighting (Discussion) .. 269

PAGE

Edridge Green, Dr. F. W. The Physiological Explanation of Glare 10

A Physiological Explanation of Miners' Nystagmus 122

Elwell Smith, H. Petrol Air Gas Lighting (Discussion) 94

Engineering Correspondent, An. Some Notes on the Lighting of the City of Leeds Training College 11

Bethnal Green Museum, Lighting of 304

Semi-Indirect Office Installation 340

Lighting of a Railway Hotel 392

Some Notes on the Lighting of Picture Palaces 476

Some Notes on the Ideal Home Exhibition 571

Indirect and Semi-Indirect Illumination in a Small House 573

Evered, J. E. The Lighting of Engineering Works by Oil .. 101

G

Gaster, L. Editorials, 1, 61, 115, 169, 235, 294, 351, 407, 447, 487, 527, 591

Annual Dinner (I.E.S.) .. 159

Economic and Hygienic Advantages of Good Illumination 280

Specification of Street Lighting (Discussion) 324

Physiological and Mental Disadvantages of Unscientific Illumination 555

Aims and Objects of the Illuminating Engineering Society 561

Report of Progress during the Vacation 613

Shadows by Natural and Artificial Light (Discussion) .. 634

Glazebrook, Dr. R. T. Annual Dinner (I.E.S.) 160

Gomme, Sir L. Annual Dinner (I.E.S.) 160

Goodenough, F. W. Annual Dinner (I.E.S.) 157

Use of Shades and Reflectors (Discussion) 145

PAGE

Goodenough, F. W. Specification of Street Lighting (Discussion) 260, 307, 325

National Gas Exhibition, Illumination at the 611

Greenslade, C. E. Lecture Theatre, Lighting of a 417

H

Harrison, Haydn T. Modern Methods of Indirect Lighting (Discussion) 39

The Lighting of Engineering Works by Electricity .. 104

Use of Shades and Reflectors (Discussion) 149

Specification of Street Lighting (Discussion) 261

Shadows by Natural and Artificial Light (Discussion) .. 632

Henninger, J. G. Shop Lighting, Some Notes on 389

Hickman, H. R. B. Modern methods of Indirect Lighting (Discussion) 44

Hoddle, C. Acetylene Lighting 67

Acetylene Lighting (Discussion) 97

Holophane, Ltd. Correspondence 638

I

Ives, Dr. H. E. Daylight, Imitation of 510

K

Kerr, Dr. James. Fourth International Congress on School Hygiene, The 616

L

Lawford, Dr. J. B. Annual Dinner (I.E.S.) 159

Lessing, Dr. R. Petrol Air Gas Lighting (Discussion) 93

Liberty, W. J. Modern Methods of Indirect Lighting (Discussion) 40

Petrol Air Gas Lighting (Discussion) 91

Centenary of Gas Lighting and its Historical Development 175

Standard Specification for Street Lighting, Some Notes on 335

PAGE

Little, T. J. Golf Putting Course, Lighting of 299

Louis, D. A. Modern Methods of Indirect Lighting (Discussion) .. 42

Luckiesh, M. The Purkinje Effect and a Comparison of Flicker and Equality of Brightness Photometers 119

Direction in Light, The Effect of 636

M

Mackinney, V. H. Modern Methods of Indirect Lighting (Discussion) 44

Mackinney, V. H., and J. G. Clark. Notes on the Use of Shades and Reflectors 125

Mackinney, V. H., and J. S. Dow. Shadows by Natural and Artificial Light 618

Shadows by Natural and Artificial Light (Discussion) .. 634

Marks, L. B. Specification of Street Lighting (Discussion) 276

Millar, P. S. Specification of Street Lighting (Discussion) 278

Minchin, H. D. Illumination as a Field for the Optometrist .. 302

Mordey, W. M. Modern Methods of Indirect Lighting (Discussion) 41

Morris, J. T. Use of Shades and Reflectors (Discussion) .. 149

Specification of Street Lighting (Discussion) 312

P

Patchell, W. H. Specification of Street Lighting (Discussion) .. 259

Paterson, C. C. Shades and Reflectors (Discussion) 151

Pearce, S. L. Specification of Street Lighting (Discussion) 327

Pierce, R. F. Exhibition Halls, Novel Method of Lighting .. 505

Pinnock, R. J. Petrol Air Gas Lighting (Discussion) 90

Prangnell, N. W. Specification of Street Lighting (Discussion) .. 326

PAGE

R

Ratcliff, H. A. Specification of Street Lighting (Discussion) .. 327

Rideal, Dr. S. Hygiene of Gas for Lighting 558

Ritchie, T. E. Modern Methods of Indirect Lighting (Discussion) 42

Use of Shades and Reflectors (Discussion) 150

Shadows by Natural and Artificial Light (Discussion) .. 631

Rumi, Prof. S. A. Specification of Street Lighting (Discussion) .. 274

S

Scott-Snell, E. Petrol Air Gas Lighting 78

Petrol Air Gas Lighting (Discussion) 98

Sharp, Dr. C. H. Specification of Street Lighting (Discussion) .. 277

Smith, R. T. Specification of Street Lighting (Discussion) 316

Strache, Prof. H. (Vienna). Street Lighting Specification (Discussion) 274

Swabacher, Dr. H. Petrol Air Gas Lighting (Discussion) 93

T

Terneden, Dr. L. J. Specification of Street Lighting (Discussion) .. 274

Thompson, Prof. S. P. Annual Dinner (I.E.S.) .. 156, 160

Some Considerations on the Brightness of Lights (National Gas Exhibition) .. 551

Thorn, F. T. Acetylene Lighting (Discussion) 90

Thorp, F. The Lighting of Engineering Works by Gas .. 99

Specification of Street Lighting (Discussion) 261

Economy of Efficient Lighting 569

Trotter, A. P. Modern Methods of Indirect Lighting (Discussion) 48

Standard Clauses for Inclusion in a Specification of Street Lighting 241, 258

Specification of Street Lighting (Discussion) 329

Sir William Preece 600

PAGE

W

Waldram, P. J. Correspondence .. 581
Use of Shades and Reflectors (Discussion) 152
Wallis-Jones, R. J. Shadows by Natural and Artificial Light (Discussion) 634
Warwick, S., and Austen Hall. School of the Future 554
Watson, R. Specification of Street Lighting (Discussion) 262
Wheat, H. C. Modern Methods of Indirect Lighting 19
Modern Methods of Indirect Lighting (Discussion) .. 48
Wheat, H. C. Use of Shades and Reflectors (Discussion) 149
Whitelegge, Sir A. Annual Dinner (I.E.S.) 160
Wilkinson, H. T. Specification of Street Lighting (Discussion) .. 274
Willcox, F. W. Modern Methods of Indirect Lighting .. 19
Modern Methods of Indirect Lighting (Discussion) .. 48

Y

Young, Dr. T. Meredith. Schoolrooms, Lighting of 198
Light and Sight 566

The Illuminating Engineering Society.

(Founded in London, 1909.)

THE ILLUMINATING ENGINEER is the official organ of the Illuminating Engineering Society, which was founded in London in 1909, with the object of providing an impartial and international platform for the discussion of problems in illumination. The journal is sent free to all members of the Society.

A glance through this Index will serve to show the great variety of subjects dealt with in the course of the year, and the influential support which the Society receives.

Forms of application for membership and all particulars can be obtained on application to the HON. SECRETARY,

Mr. L. GASTER,
32, Victoria Street, London, S.W.

NOTICE.

Owing to the great demand for Back Numbers, the cost of Vols. I.—VI. will in future, and until further notice, be **12s. 6d.** UNBOUND, and **15s.** BOUND, to NON-SUBSCRIBERS.

YEARLY SUBSCRIBERS and MEMBERS of the ILLUMINATING ENGINEERING SOCIETY, however, can obtain these volumes at a cost of **10s. 6d.** UNBOUND, and **12s. 6d.** BOUND.

Special Cases for Vols. I.—VI. of "THE ILLUMINATING ENGINEER" will be supplied at a cost of **2s.** each by

THE ILLUMINATING ENGINEERING PUBLISHING CO., LTD.,
32, Victoria Street, London, S.W.

SUBJECT INDEX.

PAGE

A

Acetylene and Petrol Air Gas (Editorial) 62
Acetylene Lighting. C. Hoddle .. 67
Acetylene Light. Photographs by (Short Notes) 109
Adrianople, No Light in (Short Note) 162
Aerial Lighthouses 470
American Museum of Safety. Good Educational Work by (Short Notes) 162
Annual Dinner of the Illuminating Engineering Society (Editorial) 115
Architectural Design, Influence of Electricity on 434
Australia, Illuminating Engineering in (Short Notes) 108

B

Bethnal Green Museum, Lighting of the. An Engineering Correspondent 304
Blind, The Education of (Short Notes) 285

C

Centenary of Gas Lighting and its Historical Development, The. W. J. Liberty 175
Centenary of Gas Supply, The (Editorial) 169
Cinematograph Theatre, Illumination, Problems in the 432
Classification of Accidents (Short Notes) 163
Clean Windows Please (Short Notes) 52
Colour Photometry and the Neon Tube (Editorial) 237
Congregation Summoned by Electric Lights (Short Notes on Illuminating Engineering) 580
Consumption, How Sunlight Slays (Short Notes) 51

CORRESPONDENCE :—

Blok, A. 638
Correspondent from Ireland .. 471
Holophane Ltd. 638
Waldram, P. J. 581
Curved Electrical Fittings, How to Wire (Short Notes) 163

PAGE

D

Daylight and Night—Which is Which ? 576
Daylight Illumination, Some Problems in (Editorial) 593
Daylight Illumination, Queries on 608
Daylight, Imitation of. Dr. H. E. Ives 510
Daylight with Gas, Artificial .. 339
Direction in Light, The Effect of. M. Luckiesh 636
Do not Read in Bed (Short Notes) 108
Dover Mishap caused by Searchlight 512

E

Economic and Hygienic Advantages of Good Illumination, The. L. Gaster 166, 280
Edison Electric Safety Lamp (Short Notes) 398
Editorials. L. Gaster 1, 61, 115, 169, 235, 295, 351, 407, 447, 487, 527, 591
Electrically Lighted Balloon, An (Short Notes) 399
Electrically Lighted Lawn Tennis Court, Another (Short Notes) 580
Electric Lighting, Cost in 1896 and 1912 Compared 300
Electric Lighting in the City of London (Editorial) 236
Electric Wiring, Modern Methods of (Short Notes) 108
Exhibition Halls, Novel Method of Lighting. R. F. Pierce .. 505

F

Factory and Industrial Lighting. (L. Gaster, T. Thorne Baker, Prof. Vivian Lewes) 602
Factory Lighting. Report of H.M. Chief Inspector 429
Factory Lighting in New York, Proposed Legislation on (Editorial) 3
Factory Lighting, New York Legislation on 16
Fatality through the Extinction of a Public Lamp (Short Notes) 163
Firelight and Electric Light (Short Notes) 109
Fourth International Congress on School Hygiene, The. Dr. James Kerr 616
French Journal on Illumination, A 454

PAGE

G

Gas Industry and Illuminating Engineering (Editorial) .. 171
Gas Industry, An Invitation to the 232
Gas Industry and Illumination .. 456
Gas Watch Fires at the Funeral of the late Emperor of Japan (Short Notes) 398
Gavel for Illuminating Engineering Society (U.S.A.), A Historic 536
German Illuminating Engineering Society, The 232
Glare from Polished Paper 494
Glare, Physiological Explanation of. Dr. F. W. Edridge Green .. 10
Golf Putting Course, Lighting of a. T. J. Little 299
Good and Bad Illumination, Some Examples of (Short Notes) .. 53
Good Lighting in the New Indian Factories Act 16

I

Ideal Home Exhibition. Engineering Correspondent 571

Illuminating Engineering Society
(Founded in London 1909)

Accounts of Meetings 18, 65, 123, 173, 239, 307, 355, 609
New Members, 18, 66, 124, 174, 240, 306, 386, 609
Modern Methods of Indirect Lighting .. .. 19—38
Do. (Discussion) .. 39—50
Notice of Annual Dinner .. 65
Acetylene Lighting .. 67—77
Do. (Discussion) .. 89—90
Petrol Air Gas Lighting 78—89
Do. (Discussion) .. 90—99
Use of Shades and Reflectors 125—144
Do. (Discussion) .. 145—154
Annual Dinner 155
Centenary of Gas Lighting 175—231
Annual General Meeting, Official Notice 240
Specification of Street Lighting 241—257
Discussion .. 258—279, 307—334
Annual General Meeting .. 355
Report of Council for Past Session 357
Interim Report on School Lighting 364
Interim Report on Library Lighting 366
Suggested Papers, List of .. 363
List of Members .. .. 368—386
Report of Progress during Vacation .. .. .. 613—616
Fourth International Congress on School Hygiene .. 616—618

PAGE

Illuminating Engineering Society. Shadows by Natural and Artificial Light .. .. .. 618—631
Do. (Discussion) .. 631—635
Illuminating Engineering Society, Two Important Meetings (Editorial) 118
What it is and what it does (Editorial) 351
Illuminating Engineering Society (U.S.A.), Annual Convention 531
Illuminating Engineering, Lectures on, at the Polytechnic (Regent Street), W. 50, 105
Illuminating Engineering in Japan 472
Illumination in Streets, The Measurement of. Dr. K. Bunte 5
Illumination in Belgium, The Proposed Government Committee on 17
Illumination as a Field for the Optometrist. H. D. Minchin 302
Illumination, in Trades affecting the Eyes 430
Illumination in Schools 557
Illumination and Modern Methods of Lighting 599
Illumination, The Coming Question 435
Illumination Arrangements at the Panama Canal (Short Notes) .. 437
Illumination and Education (Editorial) 529
Indian Factories Act on Good Lighting 16
Indifferent Examples of Shop-Lighting (Short Notes) 286
Indirect and Semi-Indirect Lighting in a Small Home. An Engineering Correspondent 573
Indirect Church Lighting 456
Indirect Gas Lighting Installation, An 394
Indirect Lighting, Modern Methods of. F. W. Willcox and H. C. Wheat 19
Indirect Lighting (Discussion on).. 39
Indirect Lighting (Editorial) .. 4
Industrial Accidents, The Prevention of (Editorial) 298
Industrial Illumination, Importance of Good (Short Notes) 52
Industrial Illumination, The British Departmental Committee on .. 107
Do. (Editorial) 61
Institution of Gas Engineers, Jubilee Meeting of 356
Insufficient Light causes Fatal Accident (Short Notes) 397
International Congress on School Hygiene 495
Do. (Editorial) 489
International Commission on Illumination, The 491
Do. (Editorial) 487

PAGE

International Electrotechnical Commission, The 494
International Medical Congress (Editorial) 449
Do. (Notes on) 451
International Road Congress (Notes on) 458
International Petroleum Committee, Forthcoming Congress of .. 306
Interior Illumination, Notes on. H. Bohle 411

L

Lantern on Rafts (Short Notes on Illuminating Engineering) .. 579
Lawn Tennis Court, Electric Lighting of a 507
Lecture Theatre, Lighting of a. C. E. Greenslade 417
Do. (Editorial) 407
Lectures on Illumination and Photometry 557
Leeds Training College, Some Notes on the Lighting of. An Engineering Correspondent 11
Legislation on Factory Lighting in New York 16
Light in Mythology and Religion (Short Notes) 286
Light: The Modern Gaoler (Short Notes) 398
Light that (nearly) Failed, The (Short Notes) 437
Light, The Soul of Art 475
Light, Ancient and Modern .. 599
Lighting of Engineering Works by Gas. F. Thorp 99
Lighting of Engineering Works by Oil. J. E. Evered 101
Lighting of Engineering Works by Electricity. Haydn T. Harrison 104
Lighting and Output (Short Notes) 285
Lighting and Architecture (Short Notes) 397
Lighting on the Beach at the Seaside (Short Notes) 437
Lighting Industry, Some Statistics of the 473
Luminous Airship Signals 396

M

Manchester, Street Lighting in .. 497
Miners' Nystagmus, Illumination and (Editorial) 117
Miners' Nystagmus, Explanation of. Dr. F. W. Edridge-Green .. 122
Miniature Lighting Installations (Short Notes) 164
Modern Circus Lighting (Short Notes) 513
Modern Illuminants and Effective Shading (Short Notes) .. 399
Moore Light, Recent Progress in the (Short Notes) 436
Motor Car Showroom, Indirect Lighting of 606

N

National and International Aspects of the Illuminating Engineering Society (Editorial) 591
National Gas Exhibition, Notice of 474
National Gas Exhibition, The .. 504
Do. (Editorial) 490, 527
National Gas Exhibition:—
Account of Proceedings at Conferences, &c. 537
Description of Exhibits 544
Papers read (Prof. S. P. Thompson, Septimus Warwick and Austen Hall, L. Gaster, Dr. S. Rideal, Dr. T. Meredith Young, Franklin Thorp) .. 551
National Gas Exhibition, Illumination at the. F. W. Goodenough 611
Needlework with Dark Materials, Illumination required for (Editorial) 450
New York, Industrial Hygiene in (Short Notes) 285
Nobel Prize awarded for Illuminating Apparatus (Short Notes) 51

O

Office Lighting and Eyesight of Clerks (Editorial) 530
Office Lighting Installation, A Modern 453
Old Forms of Lamps 438
Oriental Restaurant, Lighting of a 512

P

Panama Exhibition, Illuminated Banners at (Short Notes on Illuminating Engineering) .. 579
Petrol-Air Gas Association, The .. 10
Petrol Air Gas Lighting. E. Scott-Snell 78
Petrol Air Gas Installation, A .. 475
Photographic Dark Room, Lighting of 578
Physical Laboratory of National Electric Lamp Association, U.S.A., The (Editorial) .. 448
Picture Palaces, Notes on the Lighting of 476
Planning of Buildings and the Provision of Artificial Illumination (Editorial) 237

PAGE

Polar Curves and Light Distribution 638
Preece, Sir William (Editorial) .. 593
Do. A. P. Trotter 600
Publications Received, 56, 112, 400, 525, 582
Public Highways and Vehicles, Lighting of 458
Public Lighting in France (Short Notes) 285
"Punch" on Illumination again (Short Notes) 52
Purkinje Effect and a Comparison of Flicker and Equality of Brightness Photometers. M. Luckiesh 119

R

Railway Hotel, Lighting of a. An Engineering Correspondent .. 392
Reflectors and Globes, Notes on. A. Blok 420
Regulation of Traffic and the Lighting of Streets, The (Editorial) 447
Report of Progress during the Vacation. L. Gaster 613
Reviews of Books:—
Bezant, A. F. Competition Points for Gas Salesmen 343
Bohle, H. Electrical Photometry and Illumination 342
Clinton, W. C. The Science of Illumination 112
Clinton, W. C. Electric Wiring 442
Eck, J. Light, Radiation and Illumination 524
Matthews, W. B. Electricity for Everybody 344
Schilling, E. Kalendar für das Gas und Wasserfach 344
Shaw, E. R. School Hygiene .. 524
Uppenborn, F. Lehrbuch der Photometrie 442
Wallis, F. E. How to know Architecture 342
Review of the Technical Press 54, 110, 167, 287, 345, 401, 440, 484, 521, 583, 639
Royal Institute of Public Health:—
Paris Congress (Editorial) .. 238
Annual Congress of the (Editorial) 297
Annual Congress 433
Notice of 154

S

Salvation Army Lodging House in New York, Lighting in the (Short Notes) 513
School Lighting 106
Do. Report of Joint Committee on 364
School Lighting at Salford Technical Institute 497
Schoolrooms, Lighting of. Dr. T. Meredith Young 498

PAGE

Scientific Glassware and Illuminating Engineering (Editorial) .. 410
Semi-Indirect Office Installation, A. An Engineering Correspondent 340
Shades and Reflectors, Notes on the Use of. J. G. Clark and V. H. Mackinney 125
Do. (Editorial) 116
Shadows by Natural and Artificial Light (Editorial) 594
Do. J. S. Dow and V. H. Mackinney 618
Shop Lighting, Some Notes on. J. G. Heninger 389
Short Notes on Illuminating Engineering, 51, 108, 162, 285, 397, 436, 513, 579
Show-Window Contest, A. (Short Notes) 51
Speed Signal for Taxi's and Motor-buses, Electrically Lighting (Short Notes) 52
Standard Clauses for Inclusion in a Specification of Street Lighting:—
A. P. Trotter 241
Editorial 235, 295
Standard Specification for Street Lighting, Some Notes on:—
W. J. Liberty 335
Street Lighting (Correspondence) .. 471
Street Lighting, An Important Report on 463
Street Photometry, A Novel Suggestion for 462
Submarine Lights on the Chicago River 397

T

Trade Notes 57, 115, 165, 290, 348, 404, 443, 481, 515, 586, 642

U

Underground Railway of London, New Lighting Devices on (Short Notes) 163

V

Value of Good Illumination to Non-Technical People, Demonstrating the (Editorial) 64
Village Stream, Electricity from the (Short Notes) 162
Violet Rays in Zinc Mining .. 454

W

Workshops, The Lighting of Engineering (Editorial) 63

Y

Year's Progress, The (Editorial) .. 1
Year's Progress in Illuminating Engineering, A 595

6

The ILLUMINATING ENGINEER
ELECTRICITY · ACETYLENE · OIL · GAS
Edited by LEON · GASTER

THE JOURNAL OF SCIENTIFIC
ILLUMINATION.
OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London, 1909.)

ILLUMINATING ENGINEERING PUBLISHING COMPANY, LTD.
PUBLISHING OFFICES :—ATHENÆUM PRESS, 13, BREAM'S BUILDINGS, LONDON, E.C.
Tel. No. 2120 Central.
EDITORIAL OFFICES :—32, VICTORIA STREET, LONDON, S.W.
Tel. No. 5215 Victoria.

EDITORIAL.

The Year's Progress.

The Illuminating Engineer has now entered upon its sixth year of existence. In accordance with our usual custom at the commencement of a new volume, we propose to review very briefly some of the events of the past year. On this occasion there is no need to do so in any detail. Some of the most important developments were dealt with in the 'Report of Progress during the Vacation,' presented at the meeting of the Illuminating Engineering Society on November 19th, while others were summarized in the Report of the Council presented at the Annual Meeting.

Members of the Illuminating Engineering Society have every reason to be satisfied with the progress of the past year. The papers read have been of an exceptionally interesting and practical character, and have received considerable attention in the press. The Society has consolidated its international connexion by securing the support of many influential authorities on the Continent and the United States. Its membership has grown substantially during the year, many different professions and all the chief methods of lighting being represented. Nevertheless, in order that the Society may successfully carry out the work before it, a considerably increased membership

is to be desired, and we hope that during next year the present rate of increase will be not only maintained, but exceeded.

The Illuminating Engineering movement is now about to enter on a new stage. During the past five years much uphill work has been done, and we are glad to see that proper recognition is now being given to our endeavours, and that our efforts are meeting with encouragement. We can fairly claim to have established the need for illuminating engineering, and demonstrated its usefulness to the general public.

The proceedings at the Congress for the Prevention of Industrial Accidents in Milan; the increased attention paid to lighting in the Reports of H.M. Chief Inspector of Factories; the recommendations of the Departmental Committee on Accidents in Factories; and, finally, the announcement of the Home Secretary that a Departmental Committee on Illumination is to be formed in this country, must create a demand for improved industrial illumination. The special course of lectures on Illuminating Engineering has been repeated at the Regent Street Polytechnic, and we have again to record a large number of papers before Societies and articles in the press on the subject.

In connexion with mines the standard of lighting is rising, and as a result of the Home Office inquiry improved forms of miners' lamps are coming into use. In the same way the work that members of the Society have been doing on Committees dealing with schools, street, and library lighting will have its effect.

The discussion aroused by the public lighting investigations in Holborn, Westminster, the City of London, and more recently in Manchester, have revealed not only keenness, but a distinct advance in technical knowledge. The lighting of shops in the West-End of London is beyond question better than it used to be; and railways, particularly some of the tubes in London, are showing considerable enterprise in devising new lighting arrangements. Several of them have recently organized illuminating engineering departments.

Meantime the outlook of those concerned with the technicalities of lighting has also undergone a change. There has been a pause in the stream of inventions dealing with lamps, and this has favoured the development of appliances for directing the light—shades, reflectors, indirect and semi-indirect fixtures, &c. It is now becoming quite usual to furnish data regarding the intensity and distribution of light from lamps and fixtures, and the types of reflectors most suitable for various problems in illumination. At one time very few firms appreciated the value of a polar curve. To-day, as the display at the Optical Convention last June proved, there are quite a number of firms, both gas and electric, that pro-

vide such information, and have devised apparatus for obtaining it. A few years ago there were few people who understood anything about illumination measurements. Now the demand is growing. During the past year quite a number of firms have brought out instruments of this kind, while others are said to be about to do so.

Proposed Legislation on Factory Lighting in New York.

Readers of this Journal are aware of the efforts being made in this country to improve factory lighting. It is interesting to observe that similar steps are now being taken in the United States. In our present number (p. 16) we publish an abstract from a proposed Bill which is receiving the attention of the New York States Factory Commission. If approved, this Bill is expected to come into force from October 1st, 1913. The Bill requires, in general terms, the provision of adequate lighting of factories. Such a recommendation was also proposed by the Departmental Committee on Accidents in this country, and it is actually embodied in the latest Indian Factory Act. (See p. 16.) When in New York the writer had an interview with Mr. A. I. Elkus, chief counsel, and Mr. R. F. Wagner, the chairman, of the New York Factory Investigating Commission, who have taken a keen interest in this work, and to whose efforts the promotion of this Bill is largely due. The first step having now been taken, the enterprising action of New York will doubtless be followed in other States.

The necessity of more specific legislation on the subject of illumination has long been felt. The inclusion of a reference to illumination marks a distinct step forward. The question remains, however, how to specify exactly what is meant by "adequate illumination." This is a matter which the New York authorities are now considering, and we feel sure that they will proceed in a cautious and judicious manner in framing tentative recommendations. It will doubtless be dealt with by the Departmental Committee on Illumination about to be appointed in this country, and, in due course, by the authorities, in the other countries interested. The results of all these investigations should be collected and compared before final detailed legislation is embarked upon.

One can well understand the immense influence that legislation of this kind, even if only of a tentative and preparatory character, must exert on those concerned with industrial lighting. Hitherto we have been in the position of enthusiasts trying to induce others to appreciate the need for good illumination as we do. But once this need is recognized officially, and recommendations on the subject are incorporated in the Factory Acts, it will become a

public duty to study illumination, and a great impetus to the Illuminating Engineering Movement will be given.

As we write these words the news arrives that the *Académie Royale de Médecine de Belgique* has passed a resolution asking the Belgian Government to appoint a Commission on Illumination similar to that in existence in France. This important resolution, supplementing previous efforts in this direction, will doubtless be favourably entertained by the Government.

Indirect Lighting.

The paper read at the last meeting of the Illuminating Engineering Society by Messrs. F. W. Willcox and H. C. Wheat on 'Indirect Lighting' (pp. 19-38) contained an interesting summary of the merits of this method of illumination, and was illustrated by a great variety of views of installations. These should form a useful record on which the authors may be congratulated. At the present time indirect and semi-indirect lighting methods are being developed by quite a number of firms interested in lighting. Most of these fittings have hitherto been electrical, but indirect and semi-indirect gas units are now coming forward also. The development of these systems seems to be in the nature of a reaction against "glare," (due largely to the excessive intrinsic brilliancy of some types of modern illuminants) on which so much stress was laid in the first session of the Illuminating Engineering Society. The complete screening of the source of light from the eyes may be an advantage. There also are no doubt many cases when it is desirable for the light to be spread out over a large area, and to penetrate into every corner of the room. In these circumstances the method should be specially useful.

At the same time, we think that it would be injudicious to put this method forward as being applicable to the lighting of almost every class of building, or rooms of any size. There will always be opportunities for both direct and indirect systems; indirect and semi-indirect methods of arclighting have already been proved to possess a special field of utility.

The semi-indirect system occupies a position intermediate between direct and indirect lighting and may commend itself to many people for this reason.

The claims made that indirect lighting is "restful to the eyes" deserve fuller investigation. The comparatively small number of installations as yet in existence in England, and the short time that has elapsed since many of them were installed naturally incline one to caution before recommending general adoption of the method. It will be interesting to watch the further developments of the system.

LEON GASTER.

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of 'The Illuminating Engineer.'

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

Measurements of Illumination in the Streets.*

By Dr. K. Bunte.

ABSTRACT.

[In this article Dr. Bunte shows how the treatment of street illumination has developed from a rule of thumb process to a science. The gas engineer must now be an illuminating engineer. The illumination at any required spot may be calculated from the polar curve of light distribution. Dr. Bunte explains how the curve showing the illumination at the ground level may be mapped out for a certain lamp at a prescribed height, and how lamps should be spaced to give even effects. A table of the minimum illumination permissible in various types of streets is also given. Dr. Bunte points out some of the difficulties to be met with in street lighting, and emphasizes the need for practical measurements of illumination in order to check the calculated data. He advocates that measurements of illumination should be in a horizontal plane one metre above the pavement, and explains why such measurements are preferable to vertical values. Finally he lays stress on æsthetic considerations which must always be remembered in planning the position of the lamps and selecting the lamp-posts, globes, &c.]

At the time when the gas engineer relied upon a single type of upright lamps it was an easy task to light the streets. For he could only place the lamps the usual distance apart (15,430 meters) alternately to the right and left.

To strengthen the illumination in the principal streets he put the lamp-posts closer together; or, when he wanted to produce a specially brilliant lighting effect, he put two or more burners in the lamps. There was not much to design or calculate, and the measurement of strength of illumination on the street was, from a practical standpoint, unnecessary; one could easily see if it were light enough. There was then nothing said of illuminating engineering.

But to-day it is unfortunate that one still frequently hears the opinion expressed, that there is no need for calculations, or even measurements of illumination; this is sometimes the feeling of the practical gas engineer.

The conditions are entirely changed owing to the keen competition between the various methods of illumination, including as they do the upright burner and inverted gas burner, low-pressure high candle-power gas lamps, compressed air and compressed gas lamps; this is even more evident when other illuminants besides gas are considered. One has to choose between different types of lamps and decide upon the arrangement of them in order to produce a certain effect at the least possible cost.

To-day the gas engineer must also be an illuminating engineer; he must calculate his illumination, and then, by means of measurement, verify his results in order to be able subsequently to correct for the many small factors which are entailed in his calculations, or to estimate them with greater precision in future. There can be nothing new in what I wish to bring before you, but I hope it will be inter-

* Abstract of Paper read at a Meeting of the Verein Sächsisch-Thüringischer Gas und Wasserfachmänner: *Jour. f. Gasbel.*, Dec. 7, 1912.

esting to many to hear a brief summary of the fundamental points in the calculation and measurement of illumination.

A lamp—say, a high-pressure gas lamp of nominal 2,000 H.K.—emits different intensities in various directions. In the photometric laboratory one can calculate by well-known methods the strength of light of the lamp at these different angles, and obtain a polar curve of light distribution. From this curve one can, by various calculations and graphical construction, determine the mean lower hemispherical candle power. This quantity in general characterizes the practical value of the lamp.

Now, if one placed such a lamp about 10 metres high, one could reckon from the polar curve what strength of illumination to expect at any particular spot in the neighbourhood. The unit of illumination is the lux. A lux, formerly known as the metre-candle, is defined as the illumination which a Hefner lamp will produce upon a vertical surface 1 metre distant.

If one replaces the Hefner lamp by a source of 2,000 H.K., one metre distant, the illumination would be 2,000 lux. If one removes the surface at present receiving a certain flux of light to a further distance away, the area over which this flux of light is distributed increases as the square of the distance—*i.e.*, the illumination varies inversely as the square of the distance away. The illumination E at distance r=intensity of source J, divided by the square of the distance—*i.e.*, $E=\frac{J}{r^2}$ (the 1st Lambert law). But the light very seldom falls vertically upon the surface illuminated. In general most of the rays of light will fall at some angle with the vertical; this one calls the "angle of incidence." The entire flux of light will therefore cover a larger surface, and the strength of illumination will be correspondingly less. The law governing this diminution of illumination (the "2nd Lambert law," or "Cosine law") states that the illumination is proportional to the cosine of the angle of incidence.

The values of the cosine of angles of incidence from 0–90° are shown in the following table :—

TABLE I.

Cos 0°=1·000	Cos 30=0·866	Cos 50=0·643	Cos 80=0·174
,, 10°=0·985	,, 40=0·768	,, 60=0·500	,, 90=0·000
,, 20°=0·940	,, 45=0·707	,, 70=0·342	

Between 0° and 90° the cosine passes through values from 1 to 0, so that the illumination will be diminished by nine-tenths at an angle of incidence of 25°, and by three-fourths at 40°, two-thirds at 50°, one-half at 60°, and about one-third at 70° and about one-fourth at 75°.

By the aid of these two laws one is in the position to calculate the illumination at any desired point. Let us take, say, a lamp h metres high. We find that the illumination of a surface at a distance a metres from the foot of the lamp, measured perpendicular to the direction of the rays, is $E=\frac{J}{r^2}$ where $r=\sqrt{h^2+a^2}$. The illumination of a horizontal surface at the same place is, then, by the 2nd Lambert law, $E=\frac{J \cos a}{r^2}$, and by substituting for $\cos a$, $\frac{h}{r}$ we obtain $E=\frac{J \times h}{r^3}$; or, at a height h and at a distance from the lamp a, $E=\frac{J \times h}{(\sqrt{h^2+a^2})^3}$. From the quotient $E=J \times \frac{h}{(\sqrt{h^2+a^2})^3}$ one can now tabulate the value of $\frac{h}{(\sqrt{h^2+a^2})^3}$ for various conditions. We now obtain from the polar curve of the lamp the value of J at the required angles, and subsequently, by multiplying these figures by the factors from Table II., we get the value of the illumination at distances 1, 2, 3, &c., metres from the foot of the lamp.

Making this value the ordinate, and the distance of the foot of the lamp the abscissa, we obtain the curve of illumination of the lamp hung at a prescribed height.

These curves have been worked out or different heights for most sources of light commonly used, and are vailable for the illuminating engineer. For example, in Bertelsmann's book 'Die Verwendung des Leuchtgases,' ol. ii.).

In lighting a street one must take nto account its character, namely, whether it is a by-street or main street, r a great business thoroughfare with ery heavy traffic; the strength and llumination necessary is different in ach of these cases. The following able gives the lowest illumination ermissible (Bertelsmann):—

y-streets with little traffic	0·3–0·5 lux
y-streets with fair amount of traffic ..	0·5–1·0 ,,
lain streets	1·5–2·0 ,,
lain streets with heavy traffic and refuges ..	3·0–5·0 ,,

One has also to decide the position of he lamp-posts or the arrangement of ires overhead, as well as the safe eight for the lamps. Then one must ake into account the nature of the raffic in the street, the existence of verhead tramway wires, the possible bscuring of light by trees, and, bove all, not lose sight of æsthetic onsiderations.

Having thus determined the position nd height of the lamps, and sketched hese in the plan of the street, one next bserves the point most distant from wo neighbouring lamps, measures with he dividers its distance from each mp, and obtains from the curves the lumination which may be expected o be derived from the type of lamp sed. The illumination at this point ay be regarded as the minimum, and hould not fall below the values specified bove. The ratio of the illumination irectly under the lamp (or the maximum illumination) to this minimum lumination is called the "Diversity-oefficient." It must not be too high, nd in general should not exceed 10.

If, for instance, one is obliged, wing to the obstruction of trees, to ang the lamps low, and therefore ecides to use very powerful lamps in order to secure the specified minimum illumination at the least well-lighted spot, an unsatisfactory effect would be produced owing to the diversity-factor being too high. One should therefore choose sources of light of lower intensity and space them nearer together.

Again, supposing that, on account of the overhead tramway wires, one has placed lamps of medium intensity relatively high. One then obtains a very uniform illumination, but one needs proportionately more lamps in order to secure that the illumination nowhere falls below the specified figure. At this point the costs of construction and distribution will make themselves felt, acting as a correcting factor, and already indicating that the scheme is not an efficient one. A scheme involving stronger lights at greater distances apart, or possibly lamps hung at the sides of the road at a lower level, will therefore be considered. This example should suffice to show the nature of the preliminary calculations preceding a decision on a scheme of street lighting.

The above remarks naturally assume that the polar curves of the lamps are readily available, either from the manufacturers or in the literature on the subject, and that these values are actually reached in practice. In Berlin, and in all places which, like Berlin, use a considerable addition of water-gas, this will be true. Gasworks, however, which generate pure coal-gas will do well to test their lamps before hanging them up, and to see that the necessary adjustments for the local quality of gas are carried out.

Unfortunately, considerable deviations from the results obtained in Berlin have become apparent when the highly efficient lamps of the latest construction are used without proper adaptation to widely different conditions.

Another point which it is important to take into account is the influence of shades and reflectors. One must ascertain if the given illumination and polar curve refers to the naked lamp or to a lamp with a shade or reflector. The

esting to many to hear a brief summary of the fundamental points in the calculation and measurement of illumination.

A lamp—say, a high-pressure gas lamp of nominal 2,000 H.K.—emits different intensities in various directions. In the photometric laboratory one can calculate by well-known methods the strength of light of the lamp at these different angles, and obtain a polar curve of light distribution. From this curve one can, by various calculations and graphical construction, determine the mean lower hemispherical candle power. This quantity in general characterizes the practical value of the lamp.

Now, if one placed such a lamp about 10 metres high, one could reckon from the polar curve what strength of illumination to expect at any particular spot in the neighbourhood. The unit of illumination is the lux. A lux, formerly known as the metre-candle, is defined as the illumination which a Hefner lamp will produce upon a vertical surface 1 metre distant.

If one replaces the Hefner lamp by a source of 2,000 H.K., one metre distant, the illumination would be 2,000 lux. If one removes the surface at present receiving a certain flux of light to a further distance away, the area over which this flux of light is distributed increases as the square of the distance—*i.e.*, the illumination varies inversely as the square of the distance away. The illumination E at distance r=intensity of source J, divided by the square of the distance—*i.e.*, $E=\frac{J}{r^2}$ (the 1st Lambert law). But the light very seldom falls vertically upon the surface illuminated. In general most of the rays of light will fall at some angle with the vertical; this one calls the "angle of incidence." The entire flux of light will therefore cover a larger surface, and the strength of illumination will be correspondingly less. The law governing this diminution of illumination (the "2nd Lambert law," or "Cosine law") states that the illumination is proportional to the cosine of the angle of incidence.

The values of the cosine of angles of incidence from 0–90° are shown in the following table :—

TABLE I.

Cos 0°=1·000	Cos 30=0·866	Cos 50=0·643	Cos 80=0·174
,, 10°=0·985	,, 40=0·766	,, 60=0·500	,, 90=0·000
,, 20°=0·940	,, 45=0·707	,, 70=0·342	

Between 0° and 90° the cosine passes through values from 1 to 0, so that the illumination will be diminished by nine-tenths at an angle of incidence of 25°, and by three-fourths at 40°, two-thirds at 50°, one-half at 60°, and about one-third at 70° and about one-fourth at 75°.

By the aid of these two laws one is in the position to calculate the illumination at any desired point. Let us take, say, a lamp h metres high. We find that the illumination of a surface at a distance a metres from the foot of the lamp, measured perpendicular to the direction of the rays, is $E=\frac{J}{r^2}$ where $r=\sqrt{h^2+a^2}$. The illumination of a horizontal surface at the same place is, then, by the 2nd Lambert law, $E=\frac{J \text{ Cos } \alpha}{r^2}$, and by substituting for Cos α, $\frac{h}{r}$ we obtain $E=\frac{J\times h}{r^3}$; or, at a height h and at a distance from the lamp a, $E=\frac{J\times h}{(\sqrt{h^2+a^2})^3}$. From the quotient $E=J\times\frac{h}{(\sqrt{h^2+a^2})^3}$ one can now tabulate the value of $\frac{h}{(\sqrt{h^2+a^2})^3}$ for various conditions. We now obtain from the polar curve of the lamp the value of J at the required angles, and subsequently, by multiplying these figures by the factors from Table II., we get the value of the illumination at distances 1, 2, 3, &c., metres from the foot of the lamp.

Making this value the ordinate, and the distance of the foot of the lamp the abscissa, we obtain the curve of illumination of the lamp hung at a prescribed height.

These curves have been worked out for different heights for most sources of light commonly used, and are available for the illuminating engineer. For example, in Bertelsmann's book ('Die Verwendung des Leuchtgases,' vol. ii.).

In lighting a street one must take into account its character, namely, whether it is a by-street or main street, or a great business thoroughfare with very heavy traffic; the strength and illumination necessary is different in each of these cases. The following Table gives the lowest illumination permissible (Bertelsmann):—

By-streets with little traffic	0·3–0·5 lux
By-streets with fair amount of traffic ..	0·5–1·0 ,,
Main streets	1·5–2·0 ,,
Main streets with heavy traffic and refuges ..	3·0–5·0 ,,

One has also to decide the position of the lamp-posts or the arrangement of wires overhead, as well as the safe height for the lamps. Then one must take into account the nature of the traffic in the street, the existence of overhead tramway wires, the possible obscuring of light by trees, and, above all, not lose sight of æsthetic considerations.

Having thus determined the position and height of the lamps, and sketched these in the plan of the street, one next observes the point most distant from two neighbouring lamps, measures with the dividers its distance from each lamp, and obtains from the curves the illumination which may be expected to be derived from the type of lamp used. The illumination at this point may be regarded as the minimum, and should not fall below the values specified above. The ratio of the illumination directly under the lamp (or the maximum illumination) to this minimum illumination is called the "Diversity-Coefficient." It must not be too high, and in general should not exceed 10.

If, for instance, one is obliged, owing to the obstruction of trees, to hang the lamps low, and therefore decides to use very powerful lamps in order to secure the specified minimum illumination at the least well-lighted spot, an unsatisfactory effect would be produced owing to the diversity-factor being too high. One should therefore choose sources of light of lower intensity and space them nearer together.

Again, supposing that, on account of the overhead tramway wires, one has placed lamps of medium intensity relatively high. One then obtains a very uniform illumination, but one needs proportionately more lamps in order to secure that the illumination nowhere falls below the specified figure. At this point the costs of construction and distribution will make themselves felt, acting as a correcting factor, and already indicating that the scheme is not an efficient one. A scheme involving stronger lights at greater distances apart, or possibly lamps hung at the sides of the road at a lower level, will therefore be considered. This example should suffice to show the nature of the preliminary calculations preceding a decision on a scheme of street lighting.

The above remarks naturally assume that the polar curves of the lamps are readily available, either from the manufacturers or in the literature on the subject, and that these values are actually reached in practice. In Berlin, and in all places which, like Berlin, use a considerable addition of water-gas, this will be true. Gasworks, however, which generate pure coal-gas will do well to test their lamps before hanging them up, and to see that the necessary adjustments for the local quality of gas are carried out.

Unfortunately, considerable deviations from the results obtained in Berlin have become apparent when the highly efficient lamps of the latest construction are used without proper adaptation to widely different conditions.

Another point which it is important to take into account is the influence of shades and reflectors. One must ascertain if the given illumination and polar curve refers to the naked lamp or to a lamp with a shade or reflector. The

A Physiological Explanation of Glare.

Dr. F. W. Edridge-Green, in a recent conversation with the writer, suggested some interesting explanations of the process which takes place in the retina when we experience the sensation of glare. These speculations are highly interesting to the lighting engineer, as they seem to explain in some measure what it is that makes some systems of lighting pleasant to the eye while others are distinctly the reverse.

It will be recalled that, according to Dr. Edridge-Green's theory, vision is accomplished by the aid of the visual purple which sensitizes the liquid which is between the rods and cones in all parts of the retina. Consequently the bright image of the source of light received on the retina is, in a sense, photographed on this liquid. It becomes a "floating image."

An excellent illustration of this will be observed if the eye is fixed on some very bright object (such as the sun), and the gaze then turned in some other direction towards a dark background. One then perceives an after-image of the bright object, which often changes its relative position (just as one would expect from a floating image of this kind). Indeed, one can often observe the after-image to be ascending; this action is the natural result of the fact that the liquid on which the image is impressed tends by gravity to sink steadily downwards, and this motion naturally appears to the eye to be reversed. Sometimes, too, portions of the visual purple acted upon become detached, and we then see several distinct images.

Now "glare" is caused when the chemical action on the visual purple takes place more quickly than the process of restoration. Whenever a very bright image is formed on the retina, the contrast with adjacent operations produces this effect, and it is only when the stimulus is removed that the eye is gradually brought back to a normal state, and the image disappears. What one should do, therefore, in lighting is to avoid all extreme contrasts. If we have a bright general illumination, the eye can gradually adapt itself to it; if, on the other hand, the illumination is comparatively low, our retina can adapt itself to this too, although the process of adaptation naturally requires time. But if the eye is presented with unequal patches of light and darkness simultaneously, or to a rapid succession of light and darkness, it has no time to adapt itself, and suffers fatigue.

The question which, from a practical standpoint, we particularly desire physiologists to tell us is as follows:—*What is the maximum numerical contrast that the eye can endure in comfort?* This should not be very difficult to determine by physiological tests.

The Petrol-Air Gas Association.

It seems rather singular that up to the present time those interested in petrol-air gas lighting have not been represented by any Association similar to those existing in the case of gas, electricity, and acetylene.

Such an Association is apparently about to be formed. We understand that it will come into existence early in the New Year. This Association, if wisely guided, should be able to render great services to the petrol-air gas industry. No doubt the new Association will undertake the preparation of trustworthy data and information, and will see to it that the claims of petrol-air gas lighting are put forward in a judicious way. It is possible that an exhibition devoted to lighting, heating, and cooking may be held shortly.

Some Notes on the Lighting of the City of Leeds Training College.

By an Engineering Correspondent

General View of Leeds Training College.

ABSTRACT.

[This article contains some notes on the lighting of the Leeds Training College. The illumination was entirely designed before the erection of the building. The Assembly Hall is lighted by gas, with "Nonpareil" sun burners suspended from the ceiling. The lighting of most of the remaining room is by electricity, with Tungsten lamps and Holophane reflectors. Particulars of the consumption of gas or electricity, and the illumination produced, is given in each instance. Some interesting problems occur, an instance being the Art Room, where the illumination is furnished by a cluster of lamps in diffusing globes, suspended from the centre of the room. Either four, eight, or twelve of these can be turned on at once. This enables both the intensity and the conditions of shadow to be varied.]

The building of the large training college for teachers at Leeds was started in 1910, and was completed by September during the present year. The Institution stands in its own grounds, and is provided with libraries, workshops, gymnasium, swimming bath, &c., so that the lighting of these various rooms presented many interesting problems.

The Leeds Training College is a thoroughly up-to-date building, and the illumination has received special care. It appears that the lighting was planned out before the foundations of the building was laid, yet subsequent tests have shown that the illumination anticipated has been provided.

The room which first claims attention is the Assembly Hall (Fig. 1), which is 97 ft. long, 28 ft. broad, and 34 ft. high at the centre. A photograph of this hall, taken entirely by artificial light, is shown on the opposite page.

The lighting is accomplished by four "Nonpareil" sun-burners, particulars of which were published in a recent number of this journal.* These lamps utilize a ring of twenty-eight low-pressure inverted burners, each of which consumes 2·8 cubic feet per hour. The aggregate candle-power of the lamp is given as 2,100. The total rated power of the lamps employed is thus 8,400. As will be seen from the illustration, these lamps are placed high up on the ceiling. Besides throwing a strong light downwards, they are stated to be of considerable assistance in providing ventilation for the room. The method of placing these lamps high up out of the field of view of the audience, so as to avoid glare, is a favourable feature.

Some measurements of the illumination in the Hall are taken. It appears that over the body of the Hall there is about 8 foot-candles—quite an exceptionally high value for a hall of this size. Now, if the total gas consumption is divided by the floor area of this Hall, it will be seen that approximately 0·115 of a cubic foot of gas is consumed per square foot. The illumination is 8 foot-candles. The specific consumption of gas for the Hall may, therefore, be taken as $\frac{0.115}{8}$ *i.e.*, 0·014 cubic feet of gas per hour per lumen.

* Oct., 1912, p. 483.

This means to say, that on this system one can limit an area of about 70 square feet of floor area with an intensity of 1 foot-candle.

It will be remembered that Mr. Dow, as a result of tests of schoolrooms lighted by low-pressure gas inverted burners, suggested, as a rough rule, to allow 1 cubic foot of gas per hour per foot-candle for every 100 square feet of area to be illuminated,* but this applied to smaller rooms, with the lamps at a comparatively low level. Naturally, it is only an approximate rule, some allowance being necessary for the type of shade used and the lightness of the surroundings. However, it seems to work fairly correctly for average, well-designed installations and properly shaded lamps.

The lighting of nearly all the smaller rooms is electric. Some particulars of the lighting in these rooms were published in a recent number of *Holophane Illumination*.

* *Illum Eng.*, Lond., March, 1912, p. 121.

Fig. 2 shows a view of the gymnasium. The area of this room is, roughly, 1,570 square feet. It is lighted by ten 100-watt tungsten lamps in "I-type" Holophane reflectors, placed on the ceiling. The walls are dark red in colour, and do not give much assistance to the illumination, but it was considered necessary to allow a fair amount of light to pass out sideways on to these walls. The consumption works out to rather under ·7 watts per square foot. In the circumstances the value of 1 to 1·5 foot-candles on the floor level seems a good result.

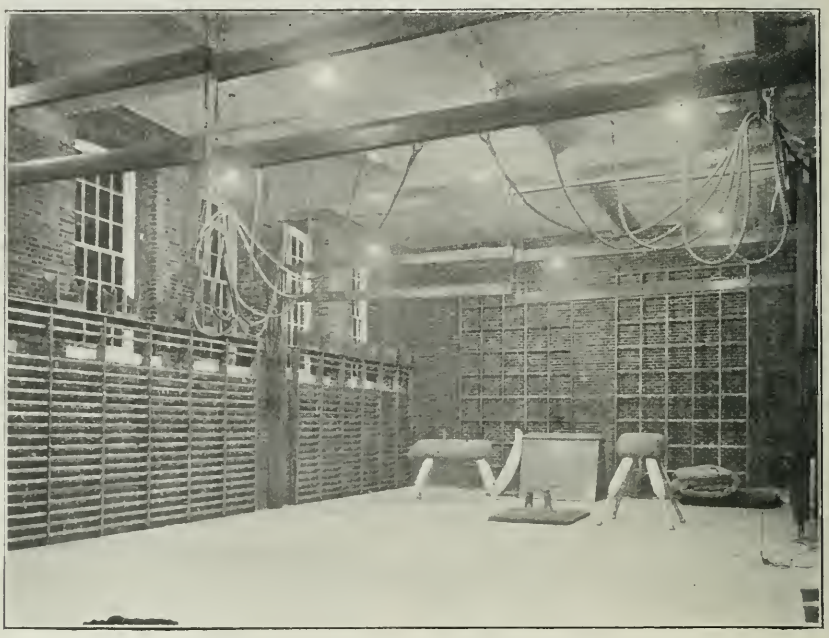


Fig. 2.—Gymnasium lighted by ten Tungsten Lamps and Holophane Reflectors. The consumption is about 0·7 watts per square foot, the illumination at the floor level from 1 to 1·5 foot-candles.

The next illustration (Fig. 3) shows a wood workshop, which is 42 ft. long and 20 ft. wide. This is lighted by fourteen 50-watt lamps in Holophane reflectors, so that the consumption is about ·8 watts per square foot. The illumination on the benches is as much as 8 foot-candles. On the blackboards a value of 3·5 foot-candles is provided.

The remaining illustration shows the Art Room. The method of lighting

FIG. 1.—Assembly Hall lighted by four "Nonpareil" sun-burners, consuming roughly one-ninth of a cubic foot of gas per square foot of floor area, the illumination produced being 8 foot-candles. The room, therefore, uses about 0·014 of a cubic foot of gas per hour per lumen.

adopted in this case is one which has been very largely used in rooms of this kind in the Midlands. A cluster of twelve 50-watt lamps in Holophane globes is placed in the centre of the room. The model usually takes up a position under the chandelier, and the students group themselves round the room as they desire, the seats and desks being movable. As much as 15 foot-candles can be obtained in the centre of the room where the model stands.

An interesting point to be noted is that either four, eight, or twelve lights can be switched on at the central chandelier. In this way the intensity of the illumination can be altered within wide limits, and the depth and sharpness of shadows can be altered at the same time. This is considered a useful thing to be able to do in Art rooms. It is not enough merely to alter the illumination according to the requirements—it is also necessary to arrange a number of lamps so that the area of the light-giving source (and hence also the sharpness of the shadows) can be adjusted by turning on more or less of the units. In conclusion, acknowledgment should be made of the courtesy of Mr. J. Falshaw-Watson, M.I.C.E., M.I.E.E., the consulting engineer for this installation, from whom some of the above particulars were obtained.

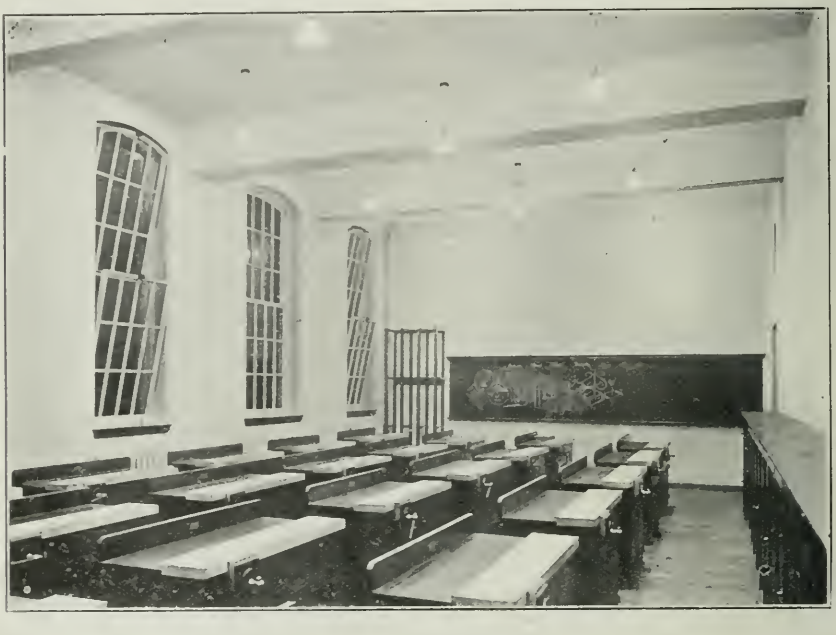


FIG. 3.—Wood workshop lighted by fourteen Tungsten Lamps and Holophane Reflectors. The consumption is roughly 0·8 watts per square foot, the illumination produced on the working plane 8 foot-candles.

FIG. 4.—Art Room lighted by a cluster of twelve Tungsten Lamps in Holophane Globes. Suspended in the centre of the room, immediately under this fitting, an illumination of 15 foot-candles can be obtained. Four, eight, or twelve lights can be switched on, and this enables the sharpness of the shadows, as well as the illumination, to be varied considerably.

Legislation on Factory Lighting in New York.

A Proposed Bill Embodying recommendations on Industrial Lighting submitted to the New York State Factory Commission.

In the November number of *Good Lighting* (*The Illuminating Engineer* of New York) reference is made to an Act now being considered by the New York State Factory Commission, with a view to improving industrial lighting. This matter is exciting much attention in Europe, and it is very gratifying to see that it is also being taken up energetically in the United States. Readers will recall that the Home Secretary in Great Britain proposes to appoint a Departmental Committee on this subject very shortly, and we trust that England will not lag behind the United States in taking action. The following is the section of the Bill containing the clauses bearing on illumination :—

"*All passage ways and all moving parts of machinery where, on or about which persons work or pass or may have to work or pass in emergencies, and all other portions of a factory that the commissioner of labor may require, shall be kept properly and sufficiently lighted during working hours.* When in the opinion of the commissioner of labor it is necessary [the workrooms], halls and stairs leading to the workrooms shall be properly *and adequately* lighted, and [in cities of the first class, if deemed necessary by the commissioner of labor], a proper *and adequate* light shall be kept burning by the owner or lessees in the public hallways near the stairs upon the entrance door and upon the other floors on every work day in the year, from the time when the building is opened for use in the morning until the time it is closed in the evening, except at times when the influx of natural light shall make artificial light unnecessary. Such lights shall be independent of the motive power of such factory.

"*All workrooms shall be properly and adequately lighted during working hours. Artificial illuminants in every workroom shall be installed, arranged and used so that the light furnished will at all times be sufficient and adequate for the work carried on therein. All artificial illuminants shall be so placed and arranged, and so shaded as to prevent strain on the vision or glare in the eyes of the workers. The advisory board to the department of labor may, pursuant to the provisions of this chapter, make and from time to time change or modify rules and regulations to provide for adequate and sufficient natural and artificial lighting facilities in all factories ; to govern the installation, arrangement, operation and use of artificial illuminants in workrooms in the different industries ; and to fix standards that shall prescribe the minimum amount of artificial illumination in such workrooms.*

"2. This act shall take effect on October the first, nineteen hundred and thirteen."

[Explanation — Matter in italics is new; matter in brackets is old law to be omitted.]

The Act thus requires "proper and adequate" illumination, but it is still necessary to define exactly what is meant by this term. The question of the exact recommendations to be made is now being considered by the Commission. Mr. A. I. Elkus, Chief Counsel, has expressed the desire that any suggestions concerning this proposed Bill should be addressed to him at the offices of the Commission (170, Broadway, New York City).

Good Lighting in the New Indian Factories Act.

The recently drafted Indian Factories Act of 1911 contains the following reference to lighting. In chap. iii., dealing with health and safety, it is laid down that :—

"1. Every factory shall be sufficiently lighted.

"2. In the case of any factory which is not in the opinion of the inspector so lighted, the inspector may serve on the manager of the factory an order in writing, specifying the measures which he considers necessary for the attainments of a sufficient standard of lighting, and requiring him to carry them out before a specified date."

A Proposed Government Commission on Illumination in Belgium.

An Important Resolution taken by the *Académie Royale de Médecine de Belgique.*

At a meeting of the *Académie Royale de Médecine de Belgique*, on December 7th, the following important communication was put forward by Dr. Motais (France) :—

"*Regarding the Technical Committee on Natural and Artificial Illumination formed by the French Government. It is proposed that similar committees should be formed in all the chief civilized countries.*

"It is proposed that a technical committee should be formed to deal with natural and artificial illumination. It appears necessary to include on this committee representatives of various aspects of the subject : oculists, physicians, gas and electric engineers, and representatives of the various Government departments interested in this question.

"The permanent committee in France has considered this proposition favourably, and M. Mirman (Directeur de l'Hygiène et de l'Assistance Publiques de France) has embodied this in an official enactment. The French Committee is already in existence, and in full activity.

"My distinguished colleague, Prof. Nuel, having taken note of the formation of our committee, has been good enough to write to me, suggesting that the organization of similar committees would be of great value to all the chief civilized nations, which are alike exposed to difficulties owing to the absence of recommendations. I submitted this project to my committee, suggesting that the French Government should take the initiative and issue an invitation on this point to all the foreign governments concerned. The committee having voted in favour of this proposition, the French Government will carry them into effect very shortly.

"If the proposition of the French Government is accepted, the various committees, after having deliberated individually, might form themselves into a Congress, and as the result of mutual discussion formulate conclusions which would serve as the basis of universal recommendations on industrial lighting.

"There can be no doubt that a recommendation to this effect issuing from such an authoritative body as the Académie Royale de Médecine de Belgique would give great force to the intention of the French and Belgium Governments. I have therefore the honour to submit to the Académie Royale de Médecine the following resolution :—

"'That this Academy, recognizing that it is essential to establish recommendations on the subject of natural and artificial illumination in factories, expresses the desire that a Technical Committee to deal with Natural and Artificial Illumination should be instituted in Belgium in order to prepare such recommendations.' (Applause.)

"In a discussion in which MM. Nuel, E. Masoin, Van Ermengem, Moeller, Motais, and M. le Président took part, the following resolution, put forward by MM. Nuel and Moeller, was put to the vote and formally accepted :—

"'*That the Académie de Médecine, having heard the views of Prof. Motais (Angers), speaking in the name of the Committee on natural and artificial illumination in France, in his capacity as general secretary of this committee, expressed the desire that the Belgian Government should follow the example of the French Government and several other foreign Governments, and nominate an official committee charged with the study of all questions bearing on natural and artificial illumination and the hygiene of vision.*'"

TRANSACTIONS

OF

The Illuminating Engineering Society

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

Modern Methods of Indirect Lighting.

A MEETING of the Society was held at 8 p.m. on Tuesday, December 3rd, 1912, at the House of the Royal Society of Arts, the chair being occupied by Mr. A. P. Trotter.

The minutes of the last meeting having been taken as read, the names of the applicants for membership* were presented in the usual way.

The Chairman then called upon Mr. F. W. Willcox to read a paper entitled 'Modern Methods of Indirect Lighting,' by Mr. Willcox and Mr. H. C. Wheat. (This will be found *in extenso* on pp. 19-38.)

An interesting discussion ensued, in which the following gentlemen took part: Mr. F. Bailey, Mr. W. J. Liberty, Prof. W. C. Clinton, Mr. C. Baker, Mr. W. M. Mordey, Mr. J. C. Clark, Mr. G. Campbell, Prof. D. A. Louis, Mr. T. E. Ritchie, Mr. V. H. Mackinney, and Dr. H. R. B. Hickman.

In conclusion, the Chairman moved a vote of thanks to the lecturers, and referred to a room lighted by the indirect system at the Paris Exhibition as far back as 1881.

He added that the next meeting of the Society would be held on Tuesday, January 14th, when papers on 'Acetylene Lighting,' by Mr. C. Hoddle, and on 'Petrol Air Gas Lighting,' by Mr. E. Scott Snell, would be read.

NEW MEMBERS OF THE SOCIETY.

THE names of the applicants for membership, read out at the previous meeting on November 19th,* were formally announced for the second time, and these gentlemen were declared Members of the Illuminating Engineering Society. In addition, the names of the following gentlemen have been duly submitted and approved by the Council, and were read out by the Hon. Secretary at the meeting of the Society on December 3rd:—

Ordinary Members.

Gibson, J.	Sales Manager to the British Westinghouse Electric and Manufacturing Co., Ltd., Long Millgate, Manchester.
Gooch, F. H.	Electrical Engineer, 96, Elgin Avenue, Maida Vale, London.
Herbert, G.	Lighting Engineer to the Benjamin Electric Co., 117, Victoria Street, S.W.
Stoeck, M.	The C.E.A.G. Electrical Safety Lamp Co. and the General Moore Electric Co., 19, St. Dunstan's Hill, London, E.C.
Thurley, C. A.	Gas Engineer, S. Metropolitan Gas Co., 21, Elynde Street, Crofton Park, London, S.E.
Van Goetham, J.	Welsbach Incandescent Gas Light Co., Gray's Inn Road, London, E.C.

* See *Illum. Eng.*, Dec., 1912, p. 549.

Modern Methods of Indirect Lighting.

By F, W. Willcox and H. C. Wheat.

(Paper presented at a meeting of the Illuminating Engineering Society, held at the House of the Royal Society of Arts (18, John St., Adelphi, London) on Tuesday, Dec. 3rd at 8 p.m.)

The artificial production of light is perhaps the most inefficient and wasteful process to be found in any branch of engineering or science. Without attempting to discuss the reasons why this should be so, it may be said that this very fact is the strongest possible argument for the necessity for "efficient" lighting, *i.e.*, for using such arrangements of artificial light sources as will most economically meet the demand for properly distributed light. Efficiency of lighting is here to be used in the wider sense of visual efficiency, and not in the narrow sense of simply physical returns for energy expended (*i.e.*, lumens or foot-candles per watt of electricity or 1,000 ft. of gas). Systems of illumination cannot always be rated in terms of energy efficiency. In the case of lighting the term "efficiency" must be used in a broader sense of general visual efficiency, by which is meant the effectiveness of the illumination secured in enabling us to *see things easily* and in comfort.

Mr. Bassett Jones, in a recent paper on interior illumination before the American Institute of Electrical Engineers, says: "The work to be done by many lighting arrangements is not only to be able to see and work with ease and comfort, but also to make the interior pleasant to the senses, and make its beauty visible. (See Fig. 1.)

"It does not follow because the light used in setting forth a design of a library is not directly concerned with the actual business of the room that therefore the lighting equipment is inefficient. In fact, only a small portion of the generated flux need be used for reading, and still the system be highly efficient, since it makes the room effective and pleasant to see and to be in, whether one reads or not. It is quite useless to have beautiful things unless one can see them, and that illumination which properly sets them off in true value as to perspective, shadow, and colour is correctly designed, no matter how much energy is necessarily and purposefully used in obtaining the correct results.

"The frescoes of St. Peter's (or nearer home the dome and architectural beauties of St. Paul's and Westminster Abbey) are wasted unless they can be seen, and for this purpose the 'working plane' of illumination is on the ceiling, and not near the floor."

Fig. 1.—Concealed lighting in St. Mary's Church, Warwick, with Tungsten lamps and metal reflectors attached to the east side of pillars and window recesses, showing the use of light to bring out the architectural features and beauties of the interior.

In approaching the subject of our discussion, not only is it necessary to have the foregoing considerations in

mind, but also to remember that light and illumination cannot be measured in physical terms alone, but involve physiological and psychological facts and considerations as well.

More stress should be laid on the necessity for natural, rational, and comfortable illumination. Some systems of lighting in vogue are not only ineffective and inefficient, but positively annoying owing to the exposure of glaring sources of light, which effectually defeat their real purpose.

Faults of this character are well stated in the following remarks of James Knox Taylor, Supervising Architect of the United States Navy :—

"For years architects have been devoting their time and talent to the designing of interiors, combining all the beauty of design possible with utility for their particular requirements. After painstaking effort, disappointment frequently results when direct lighting units are mistakenly placed on fixtures hung in the centre or around the sides of such interiors. Lumps of light—irritating, blinding sources, that lower the ceiling, shorten the room, destroy the lines, and ruin the effect the architect has striven for."

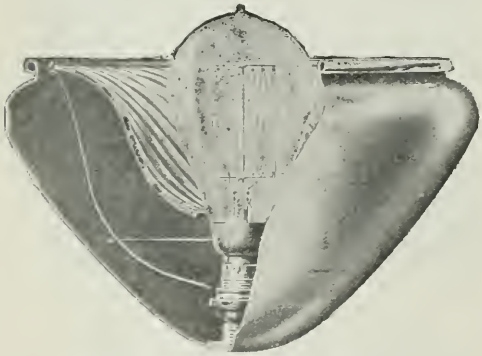


FIG. 2.—Section of "Eye-Rest" fitting, showing arrangement of lamp, reflector and bowl.

It is the object and purpose of illuminating engineering to correct these faults and deficiencies. The work of such societies as this, therefore, has an important, far-reaching, and useful purpose to serve ; it concerns the daily life of literally *every one*, for artificial lighting is the one commodity of universal use in every walk and condition of life.

Faults and deficiencies of lighting have in the past been very largely due to a lack of suitable lighting appliances. It has only been in recent years that apparatus for producing

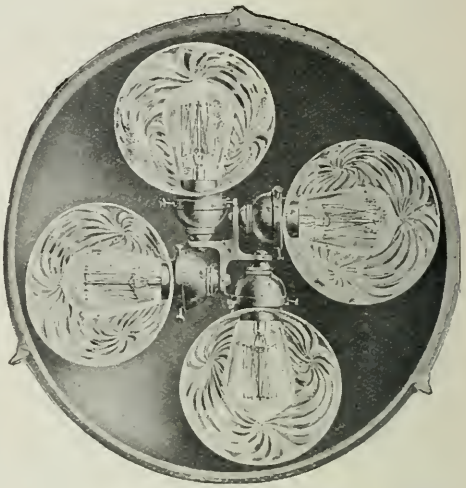


FIG. 3.—Arrangement of reflectors in 4-light "Eye-Rest" fitting.

satisfactory and effective illumination has been available. While the introduction of tungsten lamps with their great increase in efficiency has given a great stimulus to artificial lighting, yet it should be noted that as much, and even more, depends upon the efficient use of such lamps or light sources. The gains in efficiency of the sources can be further multiplied through the use of effective distributing appliances and the judicious arrangement of the lamps.

The whole subject of illumination and illuminating engineering is of quite recent date, but is now developing in a most rapid manner. Books on this subject become obsolete in a short time. Those published only two years ago scarcely make mention of the improved application which is the subject of this paper, *i.e.*, Indirect Illumination. This method of indirect illumination, which was scarcely known a few years ago, has already come into very general use.

This brings us to the subject of our discussion this evening, namely, modern

methods of indirect illumination and its advantages and merits.

Indirect Illumination.

The *idea* of indirect illumination is not exactly new. We have had indirect lighting installations in years past, the most well-known application being the "cove-lighting." According to this method lamps secreted in a groove or cove on the side walls just below the ceiling level, so that the reflected light is thrown out on the ceiling, and thus indirectly reflected on to the floor or objects. The limitations of such a system (which could frequently not be employed without structural changes in the building) and its comparative inefficiency gave rather a bad name to indirect lighting. This is responsible in a large measure for the very general impression that the indirect method of lighting is necessarily expensive and prodigal of current. The success of indirect lighting awaited the development of new and improved appliances. This result was secured by the introduction of the system known in America as "eye-comfort," and in England as the "eye-rest" system of illumination. This system of indirect lighting, as may be seen from the accompanying illustrations (see Figs. 2 and 3), employs a fixture in the form of an inverted bowl suspended from the ceiling of the room. These bowls contain highly efficient and powerful reflectors of special mirror glass construction. They are scientifically designed to give the most effective distribution of light for indirect lighting methods. (Figs. 4 and 5 show polar curves of light distribution. Fig. 6 shows the way the light is thrown to the ceiling and reflected downward.)

The reflectors used are known as "X-Ray," and consist of blown-glass blanks of correct form, which are in one piece and fire-glazed. These blanks are backed with pure silver put on by a special process, and this in turn is covered with an elastic enamel to protect and preserve it. The blanks are given a number of flutes and

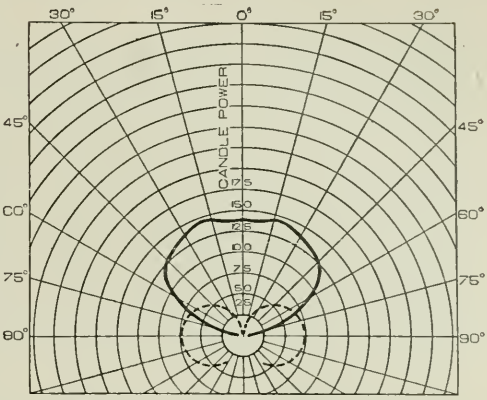


Fig. 4.—Polar curve showing light distribution from extensive X-Ray reflector.

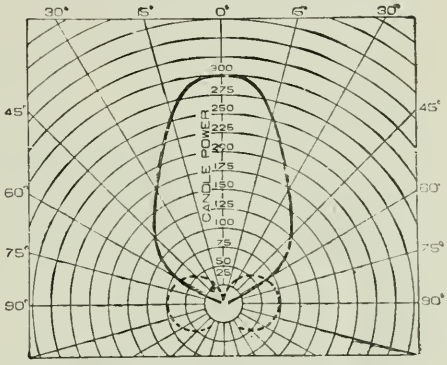


Fig. 5.—Polar curve showing light distribution from intensive X-Ray reflector.

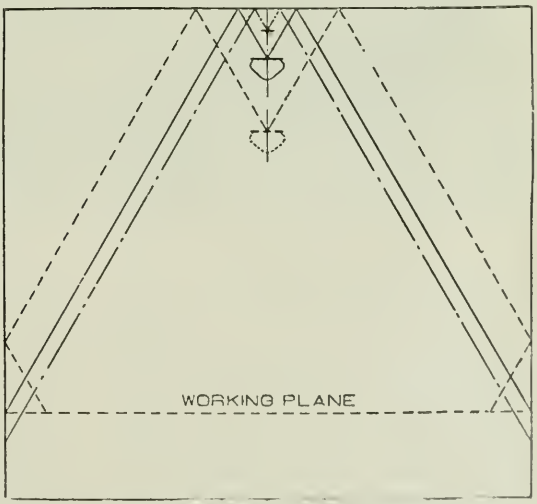


Fig. 6.—Diagram showing effect of height on light distribution from indirect fitting. Solid line shows correct distribution from properly located fitting. Dotted and chain lines show distribution with the fitting fixed too low and too high respectively.

corrugations in order to prevent striations. These reflectors as may be expected are very efficient. The accompanying polar curves (see Figs. 4 and 5) show the distribution and also disclose the fact that, of 734 lumens generated by the lamp, 612 are yielded from the reflector, which equals an efficiency of over 83 per cent —a much higher efficiency than is given by any other reflector with which the authors are conversant, although we make a point of testing all we can obtain.

It will be appreciated from the foregoing description that the reflectors are opaque, so that opaque containers are also used. The latter usually take the form of bowls, which may be of metal, wood, glass, earthenware, plaster, &c., so that, not only is there the possibility of an enormous number of different designs, but also a large selection of material from which to execute them. This makes it possible, not only to supply these fittings to suit almost any style of building, but permits of their forming part of the actual interior decoration. This form of lighting probably offers more scope in this direction than any other.

It should be noted that indirect lighting must be done in a really scientific manner to be successful, and herein lies the secret of the success of this particular system.

The success of modern indirect lighting has been remarkable, in that it was a purely practical and empirical development put forward in almost direct opposition to previous theories, and combatted by many as impracticable.

FIG. 7.—Example of direct lighting by diffusion with alba glass spheres.

In the attempt to get away from bare lights and excess brilliancy, the natural step was to increase the light-giving area. This was generally done by the use of diffusing globes over the lamps. The indirect system went a step further, and increased the light-giving area by using the largest available surface in the room—that of the ceiling. This was, however, somewhat too radical for the

ideas of many experts, who could not agree to such a solution of the problem.

Yet the first development, applied in a small way, steadily grew, and its popularity forced many to reconsider their theories on this subject, and to study the causes which have contributed to this success.

This, among other things, has led to the consideration of the physiological and psychological factors affecting satisfactory illumination. Much light has thus been thrown upon the more effective use of artificial illuminants, and upon such questions as: Why fatigue and visual depression occur to a larger degree under artificial light than with daylight? Are such faults inherent in the quality of the light itself or in the methods of its use? And, seeing that daylight is apparently so effective, how can one best produce daylight effects from artificial lights?

I propose in a later part of the paper to present a summary of some points on these questions brought out at recent discussions, in conjunction with an account of some of the tests made on this system.

Various Systems of Artificial Lighting.

In order to study the relative merits of indirect light in comparison with other methods, let us first consider and review the various systems of artificial lighting in effect to-day, which can be discussed under four headings.

In this summary, we are treating the lamps with their appliances or reflectors as a complete unit or set, and consider effects as given from the flux of light proceeding from such sets.

(*a*) *Direct Lighting* comprises systems in which the greater part of the illumination is received directly from the light units or sets of lamps and reflectors.

(*b*) *Direct Lighting*, in which the greater part of the illumination is received directly from a light source enclosed in diffusing globes, as, for example, Holophane spheres, Holophane bowls, and Alba spheres. (See Figs. 7 and 8.)

(*c*) *Semi-Indirect Lighting*, in which the light is partly transmitted directly from the lighting units through a diffusing medium, and partly indirectly by reflection from the ceiling or other surface. (See Fig. 9.)

(*d*) *Indirect Lighting*, in which *no* light is received directly on the illuminating plane, but only indirectly through reflectors from a second surface or body. In the form of indirect lighting considered under this heading the light is directed away from the objects to be illuminated and thrown upon the ceiling, from which it is reflected upon the working plane.

Fig. 8.—Alba Glass sphere fitting.

Class A.—Direct lighting with reflectors is, as is well known, by far the most generally used form of lighting.

Class B.—Direct lighting from diffusing globes or bowls comes next; the indirect and semi-indirect methods being more recent, have not come into such extensive vogue as Class A and B, but are making very rapid progress.

Let us now make a comparison of the merits of each system of lighting.

(*a*) Direct Lighting with Reflectors.

1. *Economy.*—This system of illumination admittedly offers the greatest opportunities for physical efficiency, *i.e.*, intensity of illumination as expressed in foot-candles from a given energy expenditure. This does not,

however, mean the highest general efficiency of the lighting system, using the term in its broader sense of visual efficiency.

2. *Glare, from Light Source or Reflector.*—This objectionable factor exists to the highest degree with this system of lighting, though much can be done to mitigate this defect by proper methods.

3. *Shadow Effect.*—Shadows are undoubtedly sharper and most pronounced with this system of lighting, and therefore direct lighting necessitates a larger number of lights to ensure satisfactory results on this score.

(*b*) Direct Diffused Lighting.

1. *Economy.*—The economy of diffused lighting is considerably reduced by absorption of the diffusing medium —the bowl or sphere. This reduction is considerably larger than is generally appreciated, and may easily reach 50 per cent, and with good diffusion it will be at least 20 per cent in any case.

2. *Glare.*—This is considerably reduced, particularly with certain forms of opal enclosing spheres, such as the Alba. (See Fig. 8.)

3. *Shadow Effect.* — This is undoubtedly improved, the shadow edges are not so sharply defined, although rather heavy shadows may still be produced.

Fig. 9.—Example of semi-indirect lighting with ornamental alba glass bowl fitting.

4. *Evenness of Illumination.*—While very good in an unoccupied room, difficulties arise with the presence of objects and people, so that here—as in the case of shadows—it is necessary to employ a large number of points to ensure satisfactory results.

5. *Comfort and Agreeableness.*—In general, this does not come up to the standard attainable with the other systems, although much can undoubtedly be done by proper methods to secure better results in this respect.

4. *Evenness of Illumination.*—It is difficult to definitely state its comparative value on this point, as it will depend in a large measure on the number of points and their location. It must be remembered that the low intrinsic brilliancy of suitable diffusing globes permit these to be suspended with comfort and satisfaction in or above the line of vision in positions

unsuitable for direct lighting units, and it is thus possible in many cases to secure a uniformity comparable with indirect lighting, although it must be noted that the distribution is not as definitely under control in such cases as with direct lighting, employing scientifically designed reflectors. In general, however, with an equal number of points, the system is fairly comparable in uniformity with indirect lighting.

5. *Comfort and Agreeableness.*—The system may not be as comfortable and agreeable as a properly designed direct lighting system, if the units of light (globes and spheres) have to be suspended below the line of the ceiling, and therefore act as more or less glaring sources in the line of vision. On the other hand, if sufficiently dense diffusing globes are used, the intrinsic brilliancy is low enough to give most agreeable effects, even with the sphere directly in the line of vision.

(c) Semi-Indirect Lighting.

1. *Economy.*—In actual physical efficiency this system occupies an intermediate position between direct lighting with reflectors and indirect lighting. As this system employs a diffusing bowl or globe for the direct component of the light, it is possible to have it equal and even exceed in economy the direct diffusing system of lighting (Class b).

2. *Glare.*—This depends upon the character of the diffusing bowl or globe through which the direct component of light is transmitted. With care in selecting a suitable material for this bowl or dish part of the indirect fitting (see Fig. 9), glare may be brought within reasonable limits, and in this way the system made to appear not only ahead of the direct systems (both reflecting and diffusing), but to compare most favourably, even with the complete indirect lighting system.

3. *Shadow Effect.*—Here again the results will depend upon the character and density of the bowl, or translucent bowl, or dish part of the fitting. Results of a series of tests by Thos. W. Rolph (American Ill. Eng. Soc. *Proceedings*, 1912) indicates that the percentage of the direct component in this system of lighting should not be greater than 15 per cent of the total illumination, in order to ensure shadow elimination. The container, or translucent portion thereof, should be of sufficient density to work within these limits as to control the direct component within this percentage, and where this is not the case, the system will not be comparable in shadow effects with the total indirect system, but will be found, in general, materially better than the other forms of direct illumination. A great many indirect lighting systems, however, have too great a percentage for the direct light component, and this causes objectionable shadow difficulties.

4. *Evenness of Illumination.*—This system of lighting can be arranged to give very excellent results in this direction, provided the density of the container or translucent portion of it is kept within proper limits (to make the direct component not over 15 per cent of the total illumination). In no case, however, does this system surpass the indirect lighting system on this important point.

5. *Comfort and Agreeableness of Lighting.*—Excellent results comparable with the best effects from the wholly indirect system can be secured with proper regard to the density of the translucent portion of the container, and keeping the direct component within the limit already mentioned of 15 per cent. Some tastes consider this system more agreeable than the wholly indirect system by reason of the bowl or container being translucent and bright, instead of dark underneath, as with the wholly indirect system. This feature, however, can also be introduced into the indirect system where required.

Indirect Lighting.

1. *Economy.*—While on the score of pure physical efficiency in lumens per watt, this system may stand below the others, yet in point of general visual efficiency its general results are comparable, and in many cases superior to the other systems. Even the physical efficiency of indirect lighting systems is

often considerably ahead of that of installations, which it replaces, so that the adoption of the indirect lighting system in numbers of cases actually reduces the energy consumed. We might here summarize the results of a test by Mr. J. R. Cravath on the lighting of a small room (*Transactions* of the Illuminating Engineering Society, U.S.A., 1911). Mr. Cravath made a practical test of the lighting in seven different forms. The results of the test gave the following relative efficiencies in lumens effective per lumens generated :—

	Per cent.
Direct lighting with prismatic reflectors on ceiling	52
Bare lamp at ceiling	40·9
Direct diffused lighting with 8 in. opal bowl at ceiling.. ..	33·7
Semi-indirect with inverted opal reflector	37·6
Indirect lighting ("eye rest" system)	29·5

The results of this test applied in the form of curves showing variations at different points in the room from minimum to maximum are very interesting, and indicate the following facts :—

The differences in minimum illumination were very slight, and therefore approximately the same wattage was secured for any of the methods employed. Assuming that with general illumination the amount of power required must be determined by the minimum illumination, then the differences in efficiency above noted do not indicate similar differences in the cost of lighting the room. The higher efficiencies simply indicate a surplus of illumination in those parts of the room most strongly illuminated, and therefore this surplus can be regarded as a disadvantage rather than an advantage. On this basis, *i.e.*, the greatest degree of uniform illumination with the minimum value as the determinant, the experiments do not indicate a more expensive scheme of lighting with indirect or semi-indirect systems than with other systems of lighting, *i.e.*, for the same minimum illumination. The least efficient system on the pure physical basis of average lumens per watt is about as good as the most efficient, and considering the question of glare and comfortableness of lighting there appear to be material advantages in favour of the indirect system.

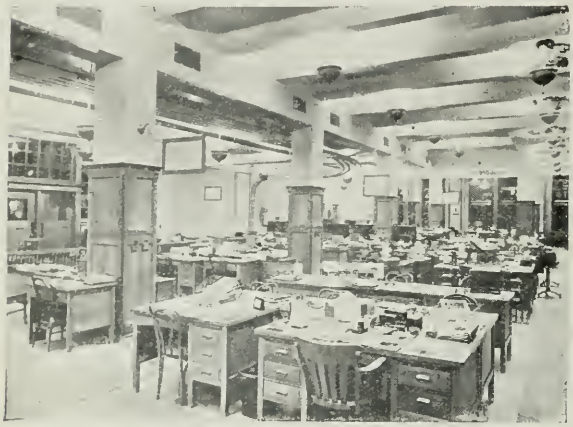


FIG. 10—Indirect Lighting in large office, showing entire freedom from glare.

Efficiencies of indirect lighting can be much higher than the foregoing result shows extending over 50 per cent in favourable cases. As the efficiency of the X-Ray mirror reflectors employed in the indirect lighting equipment is 80 per cent, and the efficiency of the average calcimined ceilings (rough and smooth) is over 76 per cent—the total efficiency of reflection would appear to be above 60 per cent with this system.

2. *Glare.*—Glare is undoubtedly reduced to the minimum by the indirect system of lighting. The lamps themselves are entirely hidden, and the greatest surface brightness, that on the ceiling, is very much lower than with any other form of lighting. The very large surface of the ceiling acts as a virtual source of lighting, giving almost perfect diffusion with an entire absence of the uncomfortable effects associated with glare. (See Fig. 10.)

3. *Shadow Effect.*—On this point the indirect lighting system stands pre-

eminent (see Fig. 11). Shadows are less dense, and the edges softer. It would be a mistake, however, to assume that this lighting is shadowless, as this would make it objectionable. It casts shadows of a character which avoid their disadvantages, and secure the advantages by preventing any flat effect that may occur under other systems of indirect lighting such as cove-lighting.

FIG. 11.- Indirect Lighting in London City Office.

It may be stated here that in comparison of shadows, one must consider the contrast between the illumination in the shadow and the surrounding illumination. This is the reason why the shadows with indirect illumination appear so much less than with direct illumination, but it should be remembered that this system of lighting is not shadowless.

4. *Evenness of Illumination.*—The indirect system of lighting surpasses all other systems in this important point and properly installed gives the best results from the fewest number of points (see Fig. 12). It is one of its important advantages that it requires

FIG. 12.—Indirect lighting in lounge of Liverpool Theatre, showing evenness of illumination secured. The walls are green and the ceiling white.

much fewer outlets than the direct system. The difference is that with the indirect system of illumination we treat the illumination of a room as a whole, while with direct lighting we may have to treat it in parts or sections.

5. *Comfort and Agreeableness of Lighting.*—On this point it may be contended that the best results of all are obtained by indirect system. A restful and beautifully diffused illumination is obtained the conditions resembling those when daylight enters a rooms through a skylight or obscured glass roof. With proper tinting of the walls the light can be toned to give rich, warm, attractive effects. Severe contrasts, glare, and heavy shadows are eliminated, with the result that the architectural features of the room appear to the best advantage (see Fig. 13.)

It is perhaps the quality of "naturalness" which makes the illuminating effects of the indirect system so comfortable and agreeable. Now it is the characteristic of good lighting to be unobtrusive, just as a healthy organ of the human body operates unconsciously, and does not distract the attention of its owner. This is characteristic of daylight and all natural effects, in which we move and act without being conscious of their presence.

In the test by Mr. Cravath on the lighting of a small room referred to, it was found that the relative comfort of the various systems stood in the following order: indirect first, then semi-indirect, and then the diffused direct light with the opal bowl.

As has been well said by Ferree, "the problem in modern lighting is not so much how to see better, as how to see with more comfort, and with less damage to the general health from eye-strain." This emphasizes the importance of comfort and agreeableness in lighting, in which features the indirect system is so markedly pre-eminent.

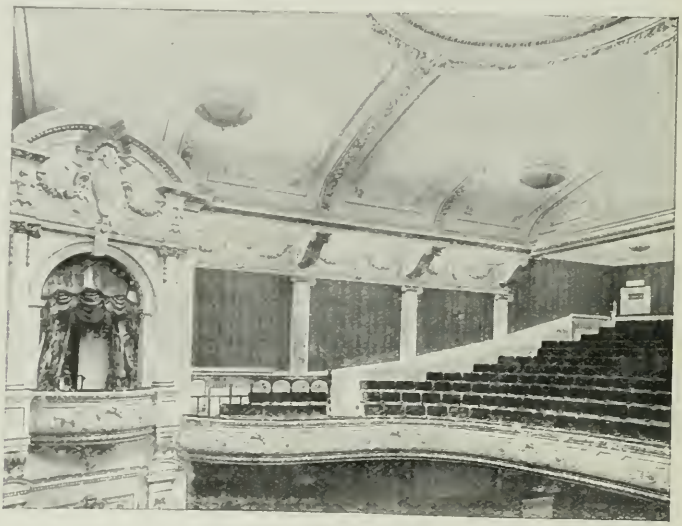


Fig. 13.—Indirect Lighting in Auditorum of Liverpool Theatre.

Considerations of the Objections to Indirect Lighting.

Passing on from this general comparison of the advantages of indirect and other forms of lighting, we can take up the discussion of the specific features and advantages, but before doing so we may with advantage consider the objections to indirect lighting. Inverted or indirect lighting is frequently subject to adverse comment on different points, and we will consider these in detail.

Brightness of Ceiling.—It is sometimes claimed that the surface brightness of the ceiling is excessive and uncomfortable, but tests made do not

confirm this claim. Tests made by Mr. Rolph show that average white calcimine ceilings both rough and smooth surface gave a reflection co-efficient of over 76 per cent, and this value was obtained quite uniformly from any point on the ceiling, *i.e.*, for any angle of incidence of the reflected light from the inverted fitting. This serves to show the large area of distribution of brightness on the ceiling, and the consequent low intrinsic brilliancy.

SURFACE BRIGHTNESS OF VARIOUS LIGHT SOURCES AND MATERIALS USED IN ARTIFICIAL ILLUMINATION.

Material.	A Candle-power per sq. in.	B Foot Candles.	C B/A.
Frosted Mazda Lamp ...	10·8	2000	185
Holophane Stiletto Reflector (brightest part) ...	4 75	1160	244
Holophane Bowls... ...	2·38	480	202
Veluria Reflector	1·83	320	175
Alba "	1·81	280	155
Opalax "	1·40	240	172
Alba Dish	·9	192	214
Ceiling above Concentrator	·12*	23	192*
Ceiling above Diffuser ...	·065*	12·5	192*

* These figures calculated only.

A number of tests on this point at Rugby yielded the results given in the accompanying table. All the tests were made with ordinary 60 watt Mazda lamps maintained at constant voltage. Two different sets of observations were carried out, one with a photometer and one with an illuminometer. Both these will be found in the table, the first column giving values of c.-p. per square inch (obtained with the photometer) taken at a distance of 10 ft. from a luminous source, and the second column giving foot-candles read on the illuminometer at a distance of 18 in. from the source. The third column gives the ratio of the first and second. It will be noted that the last figures of the table represent two different results for ceiling brightness above an inverted fitting. These two results represent the maximum value obtained with two different reflectors giving respectively a concentrating and diffusing distribution of light.

This table shows the very low degree of brilliancy and intrinsic brightness of the ceiling, and should effectually answer all criticism on this point.

The intrinsic brilliancy (in candle-power per square inch of ceiling) with indirect lighting is probably not over one-hundredth of the brilliancy with many direct lighting systems.

Brightness of Walls.—On this point we might say that there need be no such condition, since the walls can be tinted to any degree of subdued shade desirable. (See Fig. 12.) It is hard to understand, however, how the brightness of the walls can be made any objection in view of the fact that in ordinary daylight effects a large part of the illumination comes in through the windows, and is reflected from the side walls. Where the personal taste of the occupant permits brightness of the walls we have here evidence of a considerable horizontal component from indirect lighting, which has considerable value in the lighting of pictures, on the walls and the faces of the people in the room. There is no system of lighting that equals indirect lighting for bringing out the pictures on the wall, and it is the in-

FIG. 11.—Indirect lighting in Drawing-room, showing ornamentation of bowl to harmonise with the interior of the room.

variable comment of the people, seeing this system, that the "pictures look beautiful," and that people can be more easily recognized at a distance in the interiors of large buildings. This is all clearly brought out in the photographs which we show.

This horizontal component of indirect lighting is a valuable factor in the illumination of vertical surfaces, and far from being a disadvantage, is one of the advantages of indirect lighting, which is apt to be overlooked in estimating the value of the illumination solely by the amount of foot-candles given in the horizontal plane.

counteracted by the light from the other fittings. In any case, this effect can be largely reduced by employing a light coloured or white bowl, and the lower part can even be made translucent if desired. In reality, practical experience shows this point to be one of minor importance, and one soon forgotten by those using this system.

Absence of shadows; Flatness of Results.—This is a point of objection urged by many to indirect lighting systems, and is based on early experience with ineffective systems, such as cove lighting. Illumination without any shadows is of course open to certain

FIG. 15.—Special application of Indirect Lighting in Restaurant of Congress Hotel, Chicago. The Eye-Rest Bowls and Reflectors are supported by ornamental pedestals standing on the floor instead of being suspended from the ceiling.

Dark Appearance of the Under Part of the Bowl in Indirect Fittings.—This is a very natural objection, and to those who are not used to the system it is one of the first points to be raised. It can be made much or little of, depending upon the point of view, but as a matter of fact the objection disappears with a trial use of the system. The fact is more noticeable for single point installations, for example, one fitting in a room, in which case the bowl shows dark against the brighter ceiling. Where there are a number of points, however, as in the larger installations this feature is

objections in producing a flat effect, and unreal or confusing results. As we stated, however, earlier in the paper the indirect lighting with the "eye-rest" system gives rise to soft shadows, so that this objection does not hold. The shadows exist, but are not so noticeable owing to the complete diffusion of the light. It is quite a mistake to suppose that the system is "shadowless," the shadows are there, but they are modified and reduced to an unobjectionable and harmless degree. The accompanying photos taken entirely by artificial light and untouched, clearly speak for themselves on this point.

Coldness and Cheerlessness of the Light.—Such effects are not given with properly installed indirect lighting. It is possible, of course, to produce this effect by insufficiency of illumination through ineffective equipment in procuring the necessary volume of light upon the ceiling. As stated previously, the tinting of the walls can readily be employed to give any desired colour, tone, or warm effect in the resulting lighting. But in the main the objection arises through feeble illumination and the same cheerlessness would be experienced with a similar illumination obtained by direct light units above the line of vision. In other words, cold and cheerless lighting effects are apt to be produced by any form of lighting when the light results fall below a certain degree of brilliancy—so as to cause an impression of sombreness and gloom.

operating condition. It is hard to understand why there should be the objection to cleaning the fittings regularly when we consider that the furniture and fixtures of offices and homes are dusted on an average 20 to 30 times a month. Surely it cannot be much to ask and expect that lighting fixtures shall be dusted and cleaned *twice* a month.

Relative Cost of the Indirect System of Lighting.—The view that indirect lighting consumes an excessive amount of current compared with direct lighting systems has been discussed earlier in the paper. Like other criticisms this arises largely from experience with the older and other more or less ineffective forms of indirect fittings.

Figures given in a paper by Wheeler (American Illuminating Engineering Society *Proceedings*, 1912) show for an indirect lighting installation made in

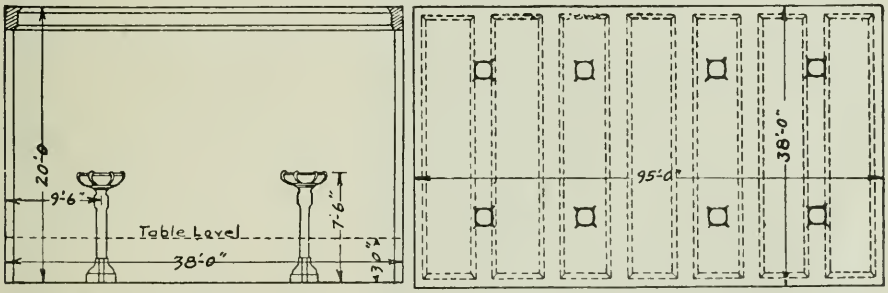


FIG. 16.—Plan of elevation showing arrangement of fittings in Congress Hotel. (Fig 18.) Four 250 watt-lamps per point.

Difficulty of Keeping the Fittings Clean.—The point has been made that the upturned fittings collect dust and dirt, which reduces the efficiency of the light by settling on the lamps and reflectors. This is valid criticism, but not a serious one. The system may require rather more attention to keep the lamps and reflectors clean than is required with some direct lighting systems, but a test of cleaning costs in the case of Armour & Co.'s offices in Chicago was considerably in favour of this indirect system as compared to the direct systems. The item is at most a small one when we consider the superior results given by the indirect system, as the reflectors and lamps need only be dusted or wiped with a cloth about twice a month to keep them in good

the village auditorium of Glenn Ellyn in U.S., the following results :—

Area of interior 40 ft. by 60 ft.

Ceiling, 15 ft. high in centre, 12 ft. at sides.

Equipment, 3 eye-rest fittings, each containing seven 100 watt tungsten lamps, and suspended 5 ft. from ceiling.

Illuminometer readings made at 30 stations :—

Average foot-candles	4·20
Watts per square foot	0·87
Lumens per watt	4·83
Watts per lumen	0·207
Per cent efficiency	56·

(Ratio total lumens generated to effective lumens.)

This excellent result was obtained with ceiling and walls of pure white

putty coat plaster, and the floor of very light maple.

In a paper read by Lansingh and Rolph (Illuminating Engineering Society of U.S.A., *Proceedings*, 1908) an efficiency of 79 per cent was stated for indirect lighting in a room with pure white ceiling, walls, and floor.

The writers have numbers of comparisons showing that the indirect lighting system of installations effect material saving in many cases in energy consumption over the previous systems which the indirect system has displaced. These comparisons, covering all classes of installations in both large and small shops, office buildings, halls, theatres, &c., are most interesting evidences of the real gains in efficiency secured by this excellent system of lighting. In making comparisons between energy consumption of indirect lighting and other systems one must not fail to consider the fact that the indirect lighting effectually lights the whole interior, and not spots or parts of it, as is generally the case with direct lighting. Indirect lighting may cost more in many cases, but it does more. If the systems of direct lighting were compelled to give equally uniform and satisfactory lighting with the indirect they would also require a material increase in wattage.

Indirect lighting has been likened to watering a flower-bed by turning the hose into the air so that the water falls on to the bed in a gently and well-diffused shower of scattered particles.

Fig. 17.—Indirect Lighting in vestibule of Liverpool Theatre.

Some Favourable Experiences of Indirect Lighting.

Indirect lighting has been adopted in some of the largest lighting installations in the world. Careful and reliable tests were carried out by several large concerns in the United States in the past year, some of the investigations extending over a period of six months at the hands of a very competent investigating committee of engineers. The various systems of illumination were fully considered and thoroughly tried in each case, and the resultant decision was in favour of indirect lighting.

The concerns in question were the following :—

The Curtis Publishing Co. adopted the equipment for the lighting of their very extensive publication buildings in Philadelphia.

The Armour Packing Co. for their establishment in Chicago.

William Filene & Sons Co. for their large department store in Boston.

In these and many other cases direct, semi-indirect, and other systems of lighting were tried and tested, and the official decision was made in favour of the "eye-rest" system of indirect lighting.

Such results render it desirable and interesting to inquire into the probable causes that contribute to such a marked preference for this system of

lighting. We can consider these under two heads :—

1. *Considerations of a physiological and psychological nature which may be responsible for the preference for indirect lighting.*

2. *Practical merits and advantages of indirect lighting, which may explain the preference shown for it.*

Under the first heading may be ncluded the following :—

Direct brilliant sources of light, such as a lamp filament cause the eye to tire and weaken more than when the light is diffused. When bright sources are in the line of vision the eyes are constantly shifting about seeking by movement to keep the light from being focussed with intensity on any one spot on the retina. Further, the discomfort from exposure of the eyes to bright sources, causes, as Dr. N. M. Black has pointed out (U.S.A. Ill. Eng. Soc. *Proceedings*, 1911), the screwing up of the eyelids and puckering of the brow and the maintaining of the pupil of the eyes in a state of constant contraction in order to exclude the excess light. The nervous energy so expended in bringing protective mechanism into play tends to produce brain tire and drowsiness, while the fatigue induced by the constant muscular contraction makes itself manifest as discomfort in and about the eye.

In ordinary systems of lighting, such as direct systems, the sources of illumination are numerous, and as a rule many lights are included within the line of vision, so that the intrinsic brilliancy of each point of light impinges upon outer portions of the retina, and uses up the visual purple of the eye needlessly.

Side-light sources, within an angle of say 26 degrees cause rays of light other than those from the object focussed to enter the eye and use up the visual purple with consequent loss of visual acuity.

In indirect lighting there is only one source of light—the ceiling—and therefore the rays are prevented from striking directly into the eye. "Glare" has been suggested by Mr. S. W. Ashe of New York to be the effect of concentrated light in the eye, which renders high intensity necessary to ensure the same sharpness on the retina. In this respect the eye may be likened to a camera photographing an object with the sun in the field of the lens. This results, as every one knows, in a fogged plate, and objects are indistinct unless they are highly illuminated. If this analogy holds, then when glare exists as with ordinary systems of lighting, the intensity would have to be raised to produce the same acuity. Thus, of two systems of lighting, the one avoiding all glare, such as the indirect lighting system, should require less intensity for equal visual acuity. This point has

FIG. 18.—Indirect Lighting in ballroom, showing effective and attractive results given.

been disputed, so that it might be well to point out that while it may be that actual visual acuity is not changed with glare, the effect of the glare is the same as though it were. Under a glaring light greater discomfort and visual depression result from the retina having the visual purple used up, as explained above, from side-light sources, &c. The cumulative result of this is to reduce the visual acuity.

Dr. Percy W. Cobb (U.S.A.) points out that it has been shown that the eye loses sensitiveness by exposure to strong light, and conversely that in the dark the eye increases in sentiveness. He says: "This phenomena has been found to depend upon the retinal change brought about by the action of the light.

"In the case of extremely bright illu-

mination, say, in a practically dark room, it is impossible for all parts of the retina to be maintained at all times at anything like the same level of sensitiveness. The part of the retina on which the image of the work falls calls for one level of adaptation, the outlying parts corresponding to the Stygian darkness of the room call for a much lower level of adaptation, *i.e.*, a higher degree to sensitiveness of the retina. Still worse when direct vision wanders, as it does, from the bright light to the darkness, the conditions of these different parts of the retina are subject to the total reversal of these effects. Such conditions of discomfort and disturbance do not, of course, occur with the indirect system of lighting."

FIG. 19.—Indirect lighting in hotel corridor.

Dr. Cobb, in discussing "glare," likens a light source in the field of vision to a loud noise in that it distracts and tends to capture one's attention. There is a strong tendency to turn the eyes toward the light source, or it may be in some cases just the reverse—to get the eyes away from it. In any case the result is distraction and annoyance in trying to use the eyes on one's subject or work, and at the same time resist the tendency to look at the light source. Certain nervous strains are thus produced which are disagreeable, and tend to cause fatigue and increase the effort of seeing.

Another effect of glare already alluded to is physiological, and is seen in the extreme in the blinding effect produced by the light from a motor-car headlight being thrown in the eyes on a dark night. Again, it is explained in one's attempt to see past a brilliant arc light, to accomplish which one has to shade one's eyes from the brilliancy. The effect of glare in this feature is to reduce the ability of the eye to see clearly.

As glare is wholly eliminated in the indirect lighting system, these effects, which fatigue and depress the visual function cannot occur.

Cravath made tests on the effectiveness of light by direct and indirect systems, by employing a number of observers to read thereunder and noting the degree of illumination considered in in each case necessary for minimum comfortable results and for ample effect. His conclusions were that under ordinary working conditions the diffuse character of the light falling on the work has more influence on the comfort of seeing and the amount of illumination required than the brightness of the surroundings.

Practical Merits and Advantages of the System of Indirect Lighting, which may explain the preference shown for it.

It has a large area of luminous surface (the ceiling or light-giving area) insuring a low intrinsic brilliancy of the luminous source, and a highly diffused character to the light. It therefore follows the diffuse lighting conditions of daylight in obtaining the working light from the largest possible surface.

One can sit in any part of a room and read with comfort, a condition not attained with other systems of lighting without employing a larger number of outlets and points.

The source of light—the ceiling—is high with the result that as the light is most excellently diffused and reflected to the lower part of the room, objects on the walls and in the room are clearly brought out. The reflected light from the objects (which causes them to be seen) is therefore not too intense, as is apt to be the case when the light sources are lower down in the field of vision.

One can assume a natural position in working or reading just as in daylight. It is not necessary to sit in any definite position or facing any one direction or hold the book or work at any given

angle. One sees satisfactorily in every position and direction, thus securing relief from (*a*) bending forward with congested positions of neck and chest, which is the customary unhealthy position the worker or reader assumes with the source of light in front; (*b*) from sitting up straight as one tends to do when the source of light is in the rear.

The excellent diffusion of light prevents heavy shadows and sharp outlines, and avoids the very objectionable regular reflection from polished surfaces. It thus removes the glare produced from the glazed paper surface of modern books and periodicals which is so uncomfortable and injurious to the eyes. One may protect one's eyes from exposed light sources by eye shades, &c., but the glare from glazed paper surfaces caused with direct lighting is difficult if not impossible to avoid. There is therefore marked advantage in the indirect lighting system, which does not produce such effects.

It brings out the beauties of design of the interior, while at the same time it gives adequate illumination for the utilitarian needs of the occupants (Fig. 13). How rarely such a combination of ornamental and utilitarian results is obtained may be realized if one studies the generality of lighting installations.

Gives a close approach to daylight effects by skylight illumination, which it is recognized gives the most excellent illumination obtainable—the ideal of perfect lighting.

Gives the greatest degree of restfulness, and soft, agreeable, and natural effect. Its results are unconsciously produced, and therefore very natural, like daylight effects.

Requires fewer outlights than other systems for equal illuminating results. Perfectly adaptable to the majority of interiors without structural changes, and with a minimum of alterations, the only conditions required being a light-coloured ceiling, either flat or arched.

Very easily and readily installed in place of existing fittings.

The bowl of fitting can be made to harmonize in ornamentation and colour with that of the ceiling or general interior. (See Fig. 14.) The bowls lend themselves to attractive effects of various kinds, *e.g.*, as hanging baskets of ferns or flowers, thus concealing their real purpose. The fittings can therefore be made objects of beauty both by day and night.

Interesting and artistic special applications can be made, which dispense with having anything suspended from the ceiling—thus giving a clear ceiling—a feature that may be preferred in some cases. This result has been accomplished in the dining-room of the Congress Hotel, Chicago, by the use of marble pillars, about 8 ft. high distributed about the room, each supporting an ornamental flower urn at top, in which the lights are concealed. (See Fig. 15.)

Fig. 20.—Indirect Lighting in office.

It satisfies most fully the real test of good illumination, namely, the ability of the eye not only to discern details distinctly, but to continue this visual effort for a good length of time with a minimum of eye strain and fatigue. Practical experience in office lighting has demonstrated a material increase of efficiency of the office force *with*

the use of indirect illumination After all it is the eye, and not the illuminometer which is the proper judge of what is the best and most satisfactory illumination.

The Application and Value of Indirect Lighting to the Various Classes of Buildings and Interiors.

We can best conclude the discussion of our subject by detailing some of the practical advantages of indirect lighting in various classes of buildings, from homes to theatres and churches.

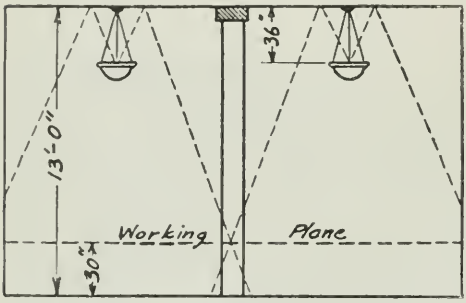


Fig. 21.—Elevation showing light distribution in the office illustrated in Fig. 20.

Theatre Lighting and Auditoriums, Ball-Rooms, Public Halls, Churches, &c. (See Figs. 13 and 17.)—It is of special importance in theatres and churches to remove all light sources, even those of moderate brilliancy, from the line of vision. The normal position of the audience brings their eyes looking slightly upwards, so that at ordinary heights exposed lights shine directly into the eyes. A person, moreover, cannot here obtain relief by turning the eyes away as can be done in an office or ordinary room.

Therefore the indirect lighting system has special application and value for this field of service.

Further its unconscious effects keep the audience or congregation from realizing that there is any source of light, and avoids any distraction of attention from the stage or pulpit.

In moving picture theatres this system of lighting permits a lighted auditorium when the pictures are being thrown on the screen—something impracticable with other lighting systems. In ballrooms (see Fig. 18) the results secured are highly effective, and the light is of the agreeable quality which social conditions require.

Hotels, Clubs, and Restaurants.—Some of the most elegant hotels in the world are lighted by the indirect lighting system. (See Fig. 19).

The restaurant of the Congress Hotel in Chicago has attracted world-wide comment, and the illumination is so agreeable that the women patrons have called it the "complexion room."

Offices, Banks, &c. (See Figs. 10 and 11.)—In offices indirect lighting renders desk or individual lights unnecessary, and gives a minimum number of fixtures. The illumination is evenly distributed so that all parts of the office are available for work. The cheerful quality and satisfactory effects of the illumination are strong factors in obtaining the highest efficiency of employees. Indirect lighting has done away with the necessity of localized lighting in offices, which has been and is responsible for an untold amount of eye troubles, headache, and nervous troubles to employees.

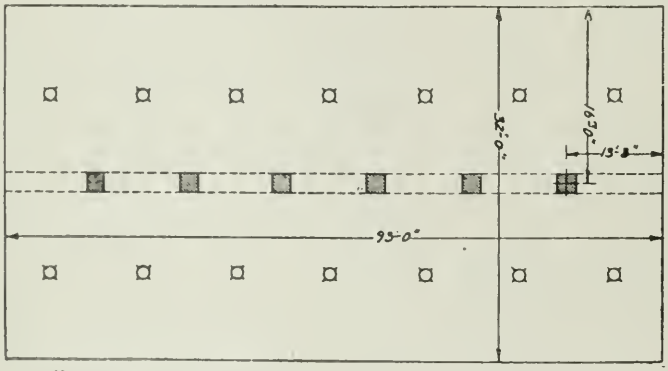


Fig. 22.—Plan of office (Fig. 20) showing arrangement of points. Three 100-watt lamps per point.

Shops and Display Rooms. Shops are most attractively illuminated by indirect lighting. No shadows are thrown from the numerous racks and goods displayed, where with ordinary lighting such shadows are unavoidable. Customers and employees are relieved from any annoying glare, and all the goods on shelves, frames, or in cases and on counters are clearly and attractively lighted.

FIG. 23.—Indirect Lighting in picture gallery. (Note the absence of high lights on the pictures.)

The system is employed to marked advantage in automobile showrooms. The light is so well distributed that every detail of the cars is clearly brought out.

Schools, Libraries, Museums, and Picture Galleries. (See Fig. 23.)—Comfortable and hygienic conditions of seeing are absolutely necessary in schools and libraries. Especially is this the case in schools where the eyesight of the children is in question.

The indirect system reproduces daylight conditions very closely, and thus gives ideal illumination for such interiors. The light is perfectly diffused, and of sufficient intensity for comfortable reading anywhere in the room.

It renders unnecessary the use of local lights or table lamps, and avoids their ill effects. Table lamps as generally employed in libraries are placed directly in front of the reader, producing irritating reflections from table and surface of paper, and inducing a forward stooping position of the reader. With indirect lighting one can read satisfactorily in any position, and a natural position can therefore be assumed in any part of the room.

In museums and picture galleries indirect lighting is wonderfully effective in reproducing skylight effects, and the exhibits of articles or pictures are brought out with wonderful distinctness.

FIG. 24.—Indirect lighting in the women's ward of Chiswick Cottage Hospital. Special dust proof fittings employed.

Hospitals. (See Fig. 24.)—The need for comfortable lighting is most marked in hospitals. The sick and suffering

should be shielded from the irritation of exposed light sources, as patients in bed in hospital wards are helpless to protect their eyes against the ills of ordinary lighting.

FIG. 25.—Indirect lighting in private house.

The softness and agreeable daylight quality of indirect lighting ensures the comfortable and soothing effects so desirable for the sick. The light can be dimmed to any desired degree of twilight effect while still retaining its perfect uniformity.

Residences. (See Figs. 14, 25, and 26.)—In the home, more than anywhere else, harmonious and restful lighting is a requisite. The word "home" spells comfort, and the lighting should contribute thereto. It is not surprising, therefore, to find that indirect lighting is finding its way into residences, and changing the irritating injurious glare and strong reflections of exposed light sources into comfortable and agreeable lighting.

Indirect lighting not only provides illumination of marked comfort, but permits the use of fixtures which harmonize with the decorations and furnishings of the room. Both from an artistic as well as from a utilitarian standpoint, indirect lighting secures the advantage that there are no lamps obtruding themselves in view, and forcibly holding the eye by their brilliancy, but instead, only an ornamental bowl, "overflowing with soft, ambient light."

Whether in the drawing-room or dining-room or bedroom, indirect lighting will be found to satisfy the various requirements in a most pleasing manner. It can be satisfactorily supplemented, like daylight, with localized illumination where required.

Some may think that we have overdrawn the merits of this system, but it is impossible to fully describe its excellent results. It must be seen to be appreciated. When properly installed under proper conditions the results given by indirect lighting surpass all that any description of it can convey, and will be found surprisingly satisfying and beyond all expectations.

FIG. 26.—Indirect lighting in drawing room.

Discussion.

The Chairman, after expressing the thanks of the meeting to the authors upon their instructive paper, invited discussion on the subject. He pointed out that as the paper had only partially been read, and had not long been in the hands of the members, it could not have received the study it deserved.

The discussion was opened by Mr. Frank Bailey, who emphasized the necessity of shading lamps, especially since the introduction of the excessively bright metallic filament lamps. The authors, he said, had rightly laid stress on the question of glare, and referred to the disastrous effect of motor-car head-lights. Glare existed, however, and would have to be endured unless some method of indirect or semi-indirect lighting were adopted.

Many of the examples shown by the authors were, he thought, capable of improvement, and more experience of both systems was wanted before any decision could be come to as to comparative merits.

He did not consider that the spotty effect of a dark globe suspended from a ceiling was so pleasant as the semi-indirect method. With the reflecting power of the semi-transparent globes a better effect was, as the authors had pointed out, obtained where only a few of the lamps were employed.

He felt that papers of the kind under discussion deserved to be addressed to non-technical audiences. The users were the persons whom it was desired to educate to the new methods, the people who, as time went on, would suffer most. In this way members might have an opportunity of placing before the public the serious dangers attending the progress of lighting when accompanied by such glare.

He hoped the paper would prove beneficial in drawing not only the attention of the members of the Illuminating Engineering Society, but of the wider public, to the indirect method of lighting.

Mr. Haydn T. Harrison said that if the system advocated were very generally adopted supply engineers would have to be congratulated, as well as the authors of the paper. He had noticed that the interesting figures given were based upon rooms with light ceilings and walls, but even under these conditions he thought the figures were somewhat in excess of what most people could afford to spend on lighting their homes. He had worked out the energy necessary on the system discussed in the paper, assuming a white ceiling and average drab-coloured walls to be contemplated, and taking the case of his own dining-room, he had found that he would require five times the amount of energy at present used to equal the present illumination.

Mr. Willcox had referred to the possibility of using a lower grade of illumination, so that the $1\frac{1}{2}$ to 2 foot-candles the speaker at present worked with could be reduced to 0·5 foot-candle. He had not had enough experience of indirect lighting to settle this point, but if it was so no doubt the amount of energy used would be sufficiently reduced to allow people to afford to use the system.

He was rather inclined to follow Mr. Bailey in his preference for the semi-indirect system. The pictures exhibited had shown the dark lower half of the fittings of the purely indirect system, and they looked very black against the brilliant ceiling.

He had gone into the question of the intrinsic brilliancy of the ceiling, and as one of the curves exhibited had shown that the reflectors produced 300 candle-power for 75 watts, and the fitting was placed within 2 ft. of the white ceiling, therefore the illumination in candle feet exactly above the fitting would be in the neighbourhood of 75; by putting three lamps into the fitting this brilliancy was increased to 200 or 210 foot-candles. On a very white ceiling this would be a high degree of

brilliancy, and a black body exactly below this very brilliant white surface would result in an effect very similar to that of glare. It was for this reason that the speaker preferred the semi-indirect to the direct system of lighting.

A discussion had recently arisen in *The Illuminating Engineer* on the question of the flatness of indirect light. In one of the slides shown by Mr. Willcox, a slide representing the interior of a room, there appeared a white statue, which could only be recognized as a statue by its outline against a dark background; the details could not be seen. To reproduce that statue in the way in which the artist carved it, it would be necessary to have the light coming from one direction; as the statue had no doubt been produced in a studio with a northern light. The details of the statue in the picture were not visible because the illumination came from all directions, which was one of the greatest objections to the indirect lighting method.

From the point of view of protecting the eyes, the method should, and he hoped would, be encouraged.

Mr. W. J. Liberty said that it would be a very good object lesson if the members would turn from the large number of photographs that had been shown that evening, and have the lights in the hall switched off to enable members to see the actual results from a demonstration in the adjoining lobby (visible through the glass screen) of a sample of indirect lighting, similar to that described by Mr. F. W. Willcox, The "dish" of this fitting was quite opaque, the ceiling white, and the walls dark, with statuary, similar to that shown in some of the photographs, which were thrown up very well; but the working plane level was not so satisfactory.

(At his request the lights were so switched off.)

Mr. W. C. Clinton thought that the shadows could be made of sufficient intensity by reducing the number of sources; a few well-selected sources would give quite enough shadow for most purposes. The uneven illumination of ceilings in indirect lighting, to which some objection had been taken, becomes necessary if objects below are to cast well defined shadows.

Mr. Charles A. Baker considered that more experimental work was necessary to provide data enabling engineers to calculate on reasonably precise lines the results that would be obtained by the use of indirect lighting.

The authors had shown some lantern-slides in which the light rays were represented as falling on the walls and floors; but the full lines and dotted lines represented *one ray* rather than the bulk of the rays, and might equally well be shown striking the ceiling at any other angle, with totally different results.

He had always found difficulty in predetermining with any degree of accuracy the results in foot-candles that would be obtained upon or within 3 ft. of the floor surface.

The height of suspension from the ceiling was a very important matter; the raising of the fitting by 1 or 2 ft. produced different effects, sometimes better, sometimes worse, being dependent upon the factors representing brilliant illumination over a limited ceiling area with the fittings suspended as high as possible, or a softer effect, generally with greater evenness, with lower suspension. Perhaps the vertical position is often decided from the point of view of taste rather than the more useful point of view of practical experience.

The effect of inverted lighting depended so much on the whiteness of the ceilings and the colour of the walls, which, of course, gradually lost that whiteness for reasons—except, perhaps, in the case of one's own private house—not within the control of the man in charge of the lighting. The architect is the man in the case of public buildings who usually regulates the cleaning and repainting at intervals of two, three, or five years, but by that time the power of the decorations to reflect rays of light will have seriously deteriorated.

When employing a system of direct artificial lighting it is often practicable for a person to increase vastly the foot-candles or lumens on a given surface by approaching the source of light—in the case of desk or table illumination, using as an example a 25 c.-p. lamp suspended 4 ft. above the desk, by rising from a sitting to a standing position an increase from 1·56 foot-candles to, say, 6·25 foot-candles is easily effected, a marked convenience for occasional purposes of everyday life—but with a system of indirect lighting such optional increase is not available. This, Mr. Baker said, was one of his reasons for putting forward the statement that 2 foot-candles of direct lighting should be replaced by 4 foot-candles of indirect lighting.

A further point that he had met in practice where some large rooms are illuminated by means of inverted arc lamps, the system is found to be additionally expensive in consequence of the energy consumed during the time occupied by the cleaners. To minimize this as far as possible, a circuit of incandescent lamps affording direct illumination has been run through the rooms to be employed instead of the inverted system whilst the cleaning of the rooms is in progress.

In one of the slides shown by the authors—that of the dining-room of a large hotel in Chicago—the light was thrown on to the ceiling from some vases supported by pedestals resting on the floor; the ceiling was cut up into panels by the girders carrying the floor above, so that the shadow effect on the side of the panels was extremely objectionable. Large buildings are now being constructed on the ferro-concrete principle in London, and he believed that one of the advantages of this form of construction was that the floors could be built comparatively thin, with greater resulting head-room for a minimum height of building. As a consequence the beams protrude about 12 in. or 15 in. below the general level of the ceiling. That kind of ceiling formation rendered the indirect systems of illumination rather more difficult, and the result not quite so pleasant.

In his view the authors had not, having regard to what they termed semi-indirect lighting with translucent bowls, attached sufficient importance to the cleaning. Bowls hung up near the ceiling were difficult to get at, and some expense would be involved if they were to be carefully cleaned very often.

It was also rather more difficult with indirect lighting to ascertain the efficiency of the lamps, which blacken unnoticed with age. The system would need a great deal of attention to keep it up to the figures given by the authors on p. 31 for the three fittings, each containing seven 100-watt tungsten lamps. These figures quoted with this example were encouraging, and the speaker hoped that they would be obtained more generally in practice, as the system would then gain in popularity, the question of pounds, shillings, and pence being an essential one.

Mr. W. M. Mordey felt that the authors should be thanked for giving expression to modern views of the lighting of interiors. It was, of course, not new—there had been many examples of indirect lighting in London for some years, for instance, the very fine dining-room in Sir Ernest Cassell's house in Park Lane.

The Building Committee of the Institution of Electrical Engineers had, when considering the lighting of the new theatre, adopted the principle that there should be no exposed lights at all. Although the results had been criticized, regular users of the theatre would agree that the lighting was quite satisfactory, even if the impression produced on entering was to a certain extent one of dimness. It was a question of the proper standard, which should be "good seeing" rather than high illumination. He thought they would agree that there was very "good seeing" in the theatre of the Institution of Electrical Engineers. The effect in relation to comfort, to which the authors had referred several times, was very good, greater than in the case of any other public building, theatre, or lecture hall with which he was acquainted.

The authors had referred to "visual

efficiency." Did they mean the relation between energy expended and the light produced, or was the intention to express the relation between light produced and effective seeing? If good seeing was the only thing that mattered, as he contended, then we must remember that people could see better with a bad light and comfort than with a good light and discomfort. The pupil of the eye took care of that. He had once been blamed by the gas journals for using the expression "whip lash on the eye" in referring to modern lamps, but he thought the general recognition of the necessity for indirect lighting justified the term.

Mr. J. G. Clark thought that the method of lighting was largely a matter of taste.

The authors had shown slides representing the illumination of churches, but he could say that he had seen photographs of church interiors, lighted by direct methods, in which the architectural features were excellently shown, and, in his opinion, were quite as good as the indirect examples shown by the authors of the paper.

He had noticed in one or two of the slides a distinct patchiness on the ceilings, and it seemed to him that such unsightliness might have been avoided if the units had been lowered by 6 in. to 12 in.; the spread of the light would have been greater, and there would have been more overlapping. The contrasts do not improve the appearance of the architecture.

The speaker then exhibited a fitting on the semi-indirect gas lighting system, pointing out that it could be easily modified to the pure indirect system, if required, although personally he preferred the semi-indirect. He had, unfortunately, no working data with regard to the system, as there were no extensive installations in London, although there were several elsewhere.

Four slides were then shown illustrating semi-direct fittings, these slides emanating from the *American Illuminating Engineer*.

Prof. D. A. Louis referred to a personal experience in the case of a living room; this room was not large, and had a dark paper. It was filled with various odds and ends that people liked to look at. Parts of the room, of course, were only to be seen by artificial light. Every kind of illumination had been tried — candles, lamps, and electric light—but the system indicated by the authors had not so far been tried.

The speaker then recounted how a visitor to the house had endeavoured to improve the lighting in various ways, such as concealing it behind double-ended cornices, picture-rails, &c. At the outset of these experiments the ceiling was, of course, white, when it was found that the effect of moderate distribution of light was better than light strongly distributed. With the subsequent discolouration of the ceiling, however, the pleasant soft light gave place to a yellowish tinge, not nearly as agreeable.

Mr. Thomas E. Ritchie, after congratulating the authors upon their paper, stated that he was, speaking generally, in complete agreement with their views. He had had an opportunity, during a recent visit to the provinces, of seeing the installation at the theatre referred to by Mr. Willcox, and could testify to the excellent results obtained, which, however, must be seen to be appreciated at their true value.

He was inclined to think that the authors had—no doubt unwittingly—conveyed a somewhat false impression as to the age of indirect lighting. The particular system to which the paper mainly related was, it is true, of comparatively recent development, but indirect lighting *per se* was of much greater antiquity than might be supposed from their remarks.

Several large installations had to his knowledge been in constant use in this country for upwards of fifteen years, and hundreds for upwards of ten.

The authors had very rightly drawn attention to the increased *visual efficiency* of indirect lighting and the more satisfactory shadow factor resulting from the increased diffusion usually obtained, and he would like to empha-

size these points by giving, firstly, the result of an interesting test recently carried out; and, secondly, some particulars of two installations which had a direct bearing upon these points.

The test was made for the purpose of determining the difference (if any) in the illumination required by the eye for the performance of the same work by direct and indirect lighting respectively.

Seven persons were tested, varying in age from 17 to 45 years, and all possessed of, as far as was known, normal sight. The test consisted in the reading of the small-type words and figures on the back of an ordinary slide-rule which was in new condition. A long room was illuminated by a single inverted arc lamp fixed at one end. The test piece was placed upon a movable desk with a sloping top similar, as regards its height and the angle of its working surface, to those usually used in commercial offices.

The desk was gradually moved away from the lamp until a point was reached at which the seven individuals only just correctly read both the letters and figures, and the illumination was then measured.

The test was repeated for the direct lighting by illuminating the working surface of the desk by a metal filament incandescent lamp suspended from a counterweight fitting, and equipped with a prismatic glass shade of a well-known make. The illumination was decreased, by raising the lamp, to a value at which both words and figures could again only just be accurately deciphered. The slide before them showed the results obtained. Taking in each case the minimum foot-candles necessary to enable the seven individuals to read the words and figures correctly, the values were :—

For direct lighting, 7·3 foot-candles ;
For indirect lighting, 1·5 foot-candles ;

or, approximately 80 per cent *less* light for the same work when applied *indirectly* than when applied directly.

The test was admittedly very critical, as the surface was glazed. An economy of from 40 to 50 per cent in the light required was, however, quite commonly met with in everyday installations, and he knew of several instances in which those wearing glasses to assist weak sight had, after some months of experience of indirect lighting, found themselves able to dispense with them.

The second slide showed the same results, with the addition of the relative measurements of the surface brightness of the ceiling in the form of curves, and incidentally disproved the theory so frequently advanced by the opponents of the system, that the higher surface brightness of the ceiling in indirect lighting rendered necessary a higher illumination on the working plane. The exact contrary was, it would be noted, found to be the case.

The next two slides were of interest, as showing the same room lighted by the "direct" and "indirect" methods. He would ask those present to notice particularly in the first slide the very hard shadows of the table at the right-hand side. In the second slide, which showed the room lighted indirectly, the shadows, though plainly discernible, had entirely lost their objectionable character, although there was no suggestion of lack of form in any of the objects depicted.

The watts per 1 foot-candle per square foot of floor area were less for the indirect than for the direct lighting. This did not, as might be thought, conflict with the statements of the authors. Their figures were for incandescent lamps, and included two reflections—the initial reflection in the fittings and the reflection from the ceiling—whilst his related to inverted arc lamps, with their considerably greater candle-power per watt consumed, and with which the loss pertaining to the first reflection was eliminated, with the result that the total gain in efficiency was very pronounced.

The last slide showed the interior of a factory lighted indirectly by inverted arcs.

In this case the watts per 1 candle-foot per square foot of floor area were slightly greater than in the direct lighting which had been replaced, but the point of interest was that the piece-work earnings of the girls engaged had, for the same period, been approxi-

mately 11 per cent greater by the indirect than by the direct lighting, full employment and the same number of girls being maintained in both cases.

The cost of lighting was about 4 per cent of the cost of manufacture, so that the advantage to the owners was of a very substantial and satisfactory character.

Mr. V. H. Mackinney congratulated the authors on their paper. He would, however, have liked to have received some more detailed information as to the nature of the indirect units described —the shaping of the reflector, and the formulæ and data utilized in their design. The distribution of illumination on the ceiling had an important effect on the nature of the shadows in a room lighted on the indirect system, and very little had been said as to what this distribution should be.

He noticed that the authors had quoted a number of tests carried out in the United States. It would be interesting to know how far these were confirmed by tests carried out by Messrs. Willcox and Wheat in this country. The figure quoted in one instance—0·2 watts per lumen—was surely an exceptional one for an indirect installation. In his experience 0·4–0·5 watts per lumen was more usual.

Very little reference had been made to semi-indirect lighting—a system which many people considered to combine the advantages of direct and indirect methods. A translucent reflector below the lamp was a useful means of avoiding the impression of "flatness" which some people complained of in indirect lighting. Bowls of this kind could be designed to have a brightness not widely different from that of the ceiling above them, whereas (as Mr. Willcox had mentioned) opaque bowls were apt to appear dead-black when seen with the highly illuminated ceiling as a background. He could confirm Mr. Willcox's estimate of 83 per cent for the reflector efficiency of his Eye-Rest units, but one might naturally expect to get a still higher efficiency with well-designed semi-indirect lighting.

Mr. Mackinney then exhibited the new Holophane semi-indirect unit. He explained that the prismatic glass bowl under the lamp reflected 75 per cent of the light upwards, and almost all the remaining 25 per cent was transmitted downwards. The loss of light in clear glass of this kind was admittedly very small. The inside of this unit was quite smooth and could be readily cleaned. There was a recess above the level of the lamp, enabling tinted glass to be inserted in order to produce a decorative effect. The fitting could be supplied in either clear glass or satin-finish.

As an illustration of the lighting conditions obtainable from the unit, Mr. Mackinney threw on the screen a diagram and photograph showing its use in a room about 14 ft. by 12 ft., and the illumination obtainable. (See p. 45.) He also displayed several slides comparing the same room lighted, first, by direct, and then by semi-indirect lighting. In the latter case a distinct "shimmer" could be seen on the table, showing that the illumination, although well diffused, was not shadowless.

In conclusion, Mr. Mackinney remarked that, although direct and semi-indirect methods had undoubtedly distinct advantages for many purposes, it was a mistake to urge their adoption in every conceivable case. There were many cases in which local direct lighting, combined with a moderate general illumination, was preferred, and rightly so.

Dr. H. R. B. Hickman had not had much experience of the indirect lighting system, but it appeared to him that, from an architectural point of view, it was excellent, but seemed a little unsatisfactory for lighting offices and such purposes. He had a feeling that he would like at least one direct unit over his left shoulder. For the decorations of theatres the indirect method was suitable. He would not, however, like to do any reading under the indirect system, which did not throw proper light on the object. Referring to motor-cars fitted with glaring lights, the visibility of an object depended on the

difference between its illumination and the illumination which was occupying the rest of the field of the retina, and this was true in the case of reading: it was impossible to work with comfort when the retinal field was "engaged," so to speak, with an illumination fully as intense as that of the image of the book occupying the yellow spot. The illumination of the room either had to be decreased in intensity, or the illumination of the book increased, and comfort in reading was greater, up to a certain point, as

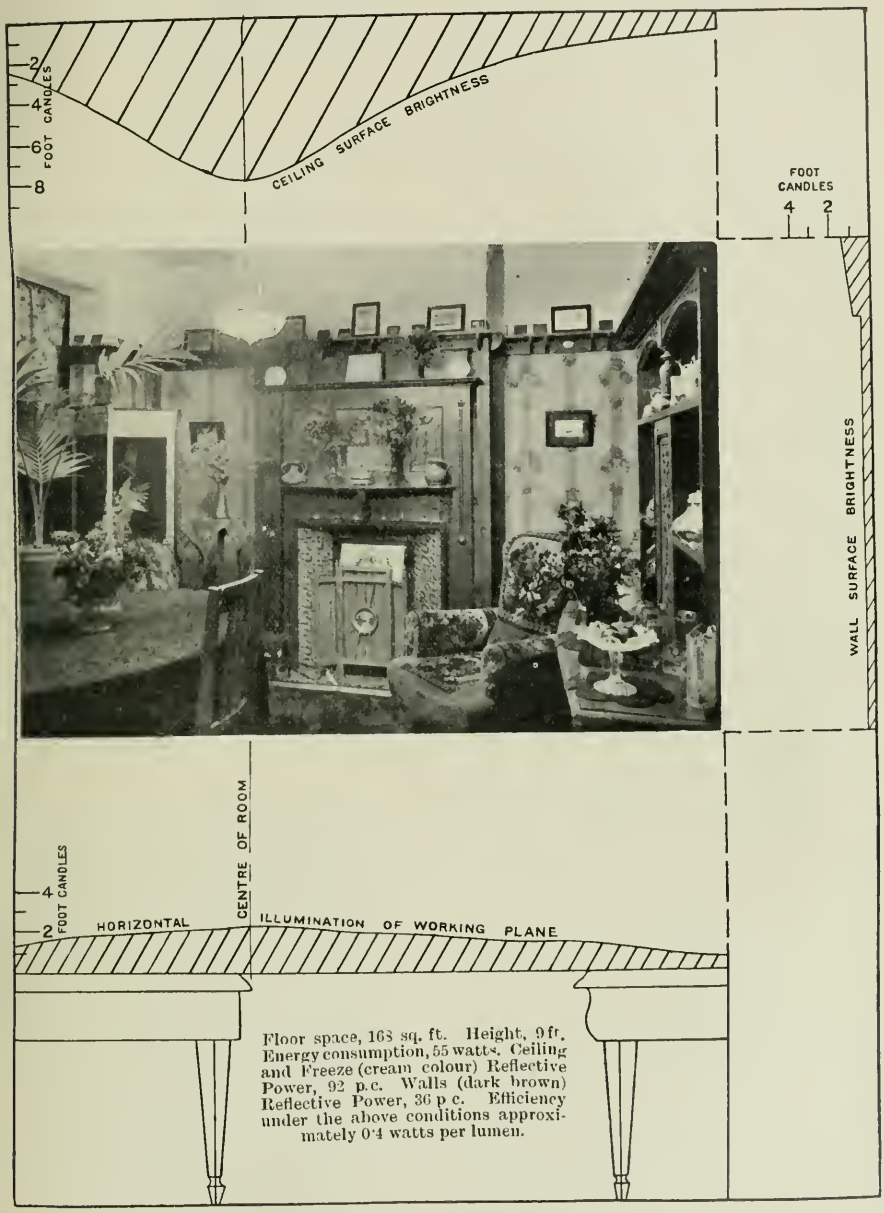


FIG. 1.—Illumination Data for Room lighted by Holophane Semi-Indirect Fitting. (Mr. V. H. Mackinney.)

both were decreased, that on the book always being kept the greater.

Mr. Guy Campbell was the next speaker. He would have been glad if more could have been heard about the working cost of the exhibited indirect lighting system in comparison with other systems. Mr. Ritchie had supplied some information on this point.

He recalled that some years ago a friend of his had received a prismatic glass reflector of the inverted type for gas lighting. By an accidental circumstance this was put up the wrong way on an upright light, with the result that his friend got one of the first known semi-indirect units for gas lighting.

With regard to the architectural features. Architects had a good deal to do with the lighting of buildings, and the mention of indirect lighting usually set them thinking of cornice lighting. The tendency was to do away with pendants of any kind. If cornice lighting could be efficiently carried out, it was often more satisfactory from the architectural point of view than suspended light units. Excellent results could be got from cornice lighting if the contour of the ceiling above the cornice was such as to lend adequate assistance.

For ordinary everyday work he considered semi-indirect a safe middle course.

The speaker then exhibited on the screen a new semi-direct unit made of an opal lower reflector bowl and white enamelled deflector. The lower bowl enclosed the lamps in such a way that there was no bright lights in the line of vision The top deflector was made of white vitreous enamel designed to distribute the light rays. If the ceiling were dirty, the deflector could still be cleaned, and good efficiency continued. The lamps in the reflector bowl were arranged by the means of a Benjamin wireless cluster body, so that the absorption was particularly low. Another slide showed the photometric curve of the lower reflector bowl, the efficiency of which was 86 per cent; of this, 72 per cent is reflected in the upward direction, the balance being diffused light from the reflector bowl.

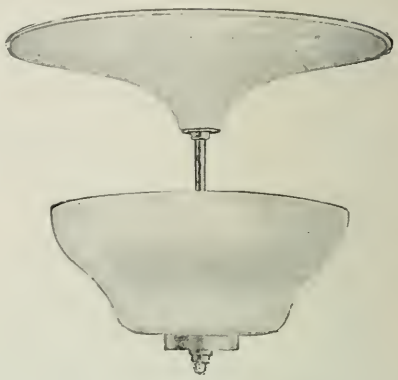


Fig. 1.—Semi-Indirect Reflector Fitting of Opal Lower Reflector Bowl and White Enamelled Deflector.

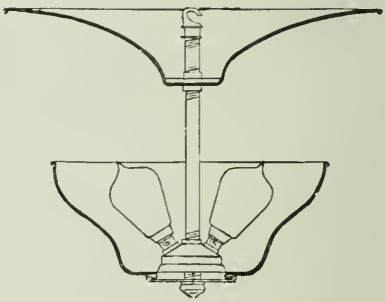


Fig. 2.—Section of the same Fitting.

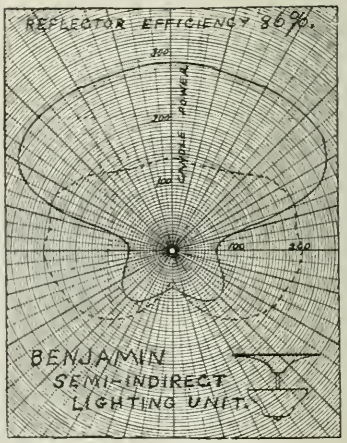


Fig. 3.—Photometric Distribution Curve of Lower Reflector Bowl.

The third slide showed the complete unit, the lamps being invisible.

Mr. John Darch (*communicated*).—I wish to congratulate Messrs. Willcox and Wheat on their most excellent paper on 'Indirect Lighting,' and the forceful and exhaustive arguments with which they have supported the principle. To me it is somewhat gratifying, for I have, for years past, pressed those same arguments — arguments which lie at the foundations of the whole principles of illumination, and which should govern every system of lighting. For *the sole purpose and object of lighting is to make properly* (*i.e.*, perfectly, readily, and comfortably) *visible the things required to be seen.* If we cannot secure this by direct lighting then we must secure it by means of indirect lighting.

The only valid argument against indirect lighting is its alleged greater cost. To produce the same amount of photometrically ascertained illumination on a horizontal working plane it is, admittedly, more costly; but photometric results are not the true basis of comparison — the physiological is the more important factor; and were it possible to measure the illumination of the retina, it would often be found quite out of proportion to that falling on the object. The greatest desiderata are diffusion and the removal of violent contrasts from the field of vision. A diffused light gives more truthful results, affords greater visual acuity, and more comfort to the eye. The removal of violent contrasts admits of a wider pupil, avoids eye-strain, and increases the retinal illumination without increasing the illuminating power. On this basis, therefore, the greater diffusive character of indirect lighting, particularly when the sources are concealed, will bring down the cost to that of direct lighting, and make the user a present of its greater charm and comfort. But even if it were dearer, we are usually ready enough to pay for comforts in other things, and why not in lighting?

It is difficult to understand why the opponents of indirect lighting are so persistent in saying that it destroys shadow and the sense of form. The example of indirect lighting on a marble bust in the lobby of the hall at the time of the discussion was a convincing demonstration of the futility of this objection, for there the shadows were strongly marked. The reverse is really the case, for indirect lighting reveals the true form of an object far better than direct lighting, in which light and shadow appear unpleasantly hard, clear-cut, patchy, and in strong contrast.

Objections were raised to the employment of indirect lighting where there are projecting beams on a ceiling. If the centre only of a many panelled ceiling bears an illuminant, the beams will, of course, spoil the job; but if each panel—and such panels are usually large—contains its own lights, or if, as I found last week, the pendants could be conveniently placed on the beams themselves, the difficulty vanishes.

This raises the question: Why should lighting, unlike everything else, be ignored by the architect when designing his building, and left to chance at the end of the job? Lighting should have its fair share of preconsideration, and the building be made to serve for the lighting that the lighting may the better serve the building.

I was glad to see the tendency of the discussion turn in favour of semi-indirect lighting, for there can be no question but that an opaque bowl, as a dark contrasting spot against an illuminated ceiling, is unpleasant. On the other hand, nothing can be more unpleasant than a bright, dazzling bowl in the field of vision. It spoils the desired effect, and lowers the scheme to the common evils of direct lighting. The reflector should, therefore, be of low translucency, and should correspond as nearly as possible in surface-brightness to that of the illuminated ceiling. It should also be a dish rather than a bowl.

I must, however, take exception to the employment of indirect lighting in hospital wards. It is excellent in every other part of a hospital, but in the ward, while it would be alright for the nurse and the doctor, the bright ceiling, always before and below the eyes of the patients, would be painful and worrying.

Again, it would appear that the

authors of the paper advocate this form of lighting for almost every purpose. There are many cases where it is distinctly inadvisable. It is excellent for every purpose where general lighting is suitable, and for most factories, museums, picture galleries, drawing-rooms, lobbies, halls, churches, &c., but, in my opinion, a dining-room, for example, should have direct and screened table lighting, a library screened adjustable desk lights, while watchmakers, engravers, dressmakers, and the like need powerful local lighting; and so with the illumination of any object needing emphasis; but in most of these cases it may be desirably combined with a low general indirect illumination.

With these exceptions I most warmly support all that has been said by Messrs. Willcox and Wheat.

The Chairman observed that the subject of the paper had been spoken of as an up-to-date method, but he remembered the opening chapter of the history of electrical engineering—the Paris Exhibition of 1881, where there was a room lighted by an arc light in a large bowl 10 ft. or 12 ft. in diameter, white-washed inside, the height from the ground being 7 ft. or 8 ft. This bowl gave a beautiful illumination.

The impression had always existed that this method of lighting was expensive, but the results indicated by the figures laid before the members showed that there was not the great loss generally anticipated. What remained to be done was to apply the method properly.

The author had spoken of halls and stair lighting, and the speaker confessed that he thought the example of the Institution of Electrical Engineers was disappointing and depressing, and might be improved by increasing the illumination.

He felt that the indirect lighting system was more important for domestic work than for office work. Many people liked a dark office and a well-illuminated table. For domestic work a well and carefully designed form of semi-indirect lighting was the most restful. He had on more than one occasion described how he had used this system at home. He used, almost entirely, candle shields, which were much larger than usual, against a white wall, and if the distance between the light and the shield were carefully adjusted the intrinsic brightness was the same on the shield as on the wall; an extremely soft effect was produced, and one which was not at all wasteful.

Mr. H. C. Wheat, in replying to the discussion, remarked that, as several of the speakers had referred to the same points, he would endeavour to cover these at one time in his reply.

Mr. Bailey had indicated a preference for the semi-indirect system. The authors had no wish to infer that there was not any field for this class of illumination. The essential feature of good semi-indirect lighting is that the density of the bowl should be such as to ensure that the amount of transmitted light is kept within a reasonable minimum.

Mr. Harrison had referred to the question of economy, but he (the speaker) contended the case was not nearly so bad as people might be led to believe from Mr. Harrison's remarks, more especially as regards the effect of dark walls. In an American test of indirect lighting with X-ray reflectors, which was made in a room with a white ceiling and black walls, an efficiency of 1·66 lumens per watt was obtained. Re-tested with the black covering removed from the walls, which were then yellow, the efficiency was raised to 2·43 lumens per watt. The discrepancy between these figures is very much less than that suggested by Mr. Harrison's calculations.

With regard to the question of contrast between the bright ceiling and the under side of the bowl, this was not so marked as people might believe—even in a room with a single unit; and in the case of larger interiors, using several units, the effect was very slight. Several speakers during the evening had referred to the comfort of reading in a room by means of a local light, the rest of the room being in comparative darkness. Such a matter was, of course, largely a ques-

tion of personal opinion, but it was not generally accepted as good practice in illuminating engineering work, supplementary general lighting always being advocated; at any rate, the contrast in this case was very much greater than between the bowl and the ceiling in inverted lighting. In ordinary cases of direct lighting the contrast between the darkest and brightest point would be very much greater. This fact was borne out by the figures which were given in the paper.

Mr. Harrison had laid particular emphasis on the fact that the shadows from inverted lighting were not sufficient to give a proper sense of solidity. He cited as an instance a slide that had been shown that evening, in which a piece of statuary was visible. The reason why this statuary did not show properly with the slide in question was due to a purely photographic reason, namely, the unavoidable over-exposure of the light parts in order to secure adequate exposure to the darker regions. This over-exposure would, as all photographers know, result in flatness. The speaker again showed a slide (Fig. 13) of the auditorium of a theatre, in which the moulded plaster decoration was clearly brought out under the indirect lighting. Mr. Harrison thought that possibly the mouldings were of a different colour to the surrounding surface, which would account for their coming out so distinctly in the photographs. But the fact that some of the mouldings *were* tinted would not alone produce the effect of solidity. If the bowls of the inverted fittings themselves were examined (probably the most severe test), it would be observed that the tinted portion was clearly seen in the photograph, but that the mouldings of the other portions were equally well defined.

Mr. Baker had asked for detailed information as to the results which could be obtained from indirect lighting; he could not readily enter into these data in the time available, but would be pleased to place any desired data which was available at his (Mr. Baker's) disposal. Mr. Baker had also referred to the difficulty of maintaining the ceiling in a good condition for inverted lighting. The speaker's experience was that with electric lighting there was no difficulty in this. Moreover, the condition of the ceiling could not by any means be neglected in the case of direct lighting; this was illustrated by the data issued by the makers of reflectors for direct lighting purposes, showing how the colour of the ceiling affected the result.

As regards the question of inverted lighting in ferro-concrete buildings, the ceiling of which was broken up into panels by deep beams, there was no difficulty, as a rule, owing to the fact that the panels were large ones, and each could have its own unit. Such an arrangement was illustrated in several of the photographs in the paper. It was admitted that a ceiling which was very much broken up by deep beams was not suited to inverted lighting.

With regard to the question of cleaning, he had in his own home an inverted fitting which was cleaned about once in four months, and that involved no great inconvenience. In lofty buildings he advocated the provision of suitable gear to enable the fittings to be lowered for cleaning and lamp renewals. Such an arrangement was in use in the Liverpool Theatre, of which photographs had been shown during the evening, and these permitted the fittings being brought down to floor level, a distance of about 50 ft.

As regards the cost of installation, inverted lighting as a rule required fewer points than direct lighting, especially where shadows had to be taken into consideration. In a small room where four direct points would be required, a better result would be obtained from one inverted unit.

He would like to explain to Mr. Mordey that they (the authors) did not claim as a novelty indirect lighting *per se*; the novelty consisted in the special ("Eye-Rest") system. The speaker had used indirect lighting with incandescent gas ten or eleven years ago by inverting an ordinary billiard shade over an incandescent burner, so

as to direct the light upwards to the ceiling.

He was glad to learn that Mr. Mordey confirmed their claim that a lower foot-candle intensity could be used with indirect than with direct lighting to obtain the same visual efficiency.

Mr. Clarke had drawn attention to the patchiness of the ceiling, as shown in some of the photographs. As the general aim was illumination of the room, the ceiling was in the majority of cases left to take care of itself, but where desired it was not difficult to arrange for an even distribution of light over the ceiling.

The speaker next showed a photograph (Fig. 11) as a reply to the point raised by Prof. Louis regarding the gloom in the lower part of the room. This illustration showed that the walls were evenly illuminated right down to the floor level, every detail of the carpet being clearly visible.

Mr. Mackinney directed attention to the preference of many people for local lighting. While this was true, it was undoubtedly due to the fact that, in the majority of cases, direct lighting did not provide satisfactory general illumination. The speaker's experience was that people were perfectly satisfied with general illumination by indirect lighting. It is rather questionable as to whether the average person is a good judge of what is good for them in artificial lighting, judging by the way artificial illuminants are generally misused.

The Chairman then brought the proceedings to a conclusion by announcing that the next meeting would take place on Tuesday, January 14th, when papers on 'Acetylene Lighting,' by Mr. Hoddle, and on 'Petrol Air Gas Lighting,' by Mr. E. Scott Snell would be read.

A COURSE OF SIX LECTURES

ON

ILLUMINATING ENGINEERING

will be given by **Specialists,** arranged by

LEON GASTER Esq., Editor of *The Illuminating Engineer.*

AT

THE POLYTECHNIC, 307-311, Regent Street, London, W.

ON

FRIDAY EVENINGS, at 7.30 o'clock, commencing JANUARY 17th, 1913.

SUBJECTS OF LECTURES.

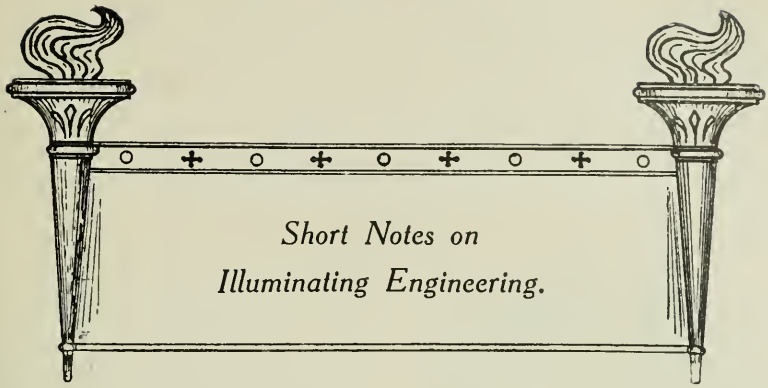
I.	Jan. 17th.	Illumination and the Eye, Dr. W. J. Ettles, F.R.C.S.E.
II.	Jan. 24th.	The Measurement of Light and Illumination, J. S. Dow, B.Sc., A.C.G.I.
III.	Jan. 31st.	Shades and Reflectors, by J. S. Dow, B.Sc., A.C.G.I.
IV.	Feb. 7th.	Colour in Illumination, by J. S. Dow, B.Sc., A.C.G.I.
V.	Feb. 14th.	Practical Lighting Problems: 1. Indoor Lighting, by J. S. Dow, B.Sc., A.C.G.I.
VI.	Feb. 21st.	Practical Lighting Problems: 2. Outdoor Lighting, J. S. Dow, B.Sc., A.C.G.I.

Fee for the Course of 6 Lectures ... ... **6s. 0d.**

Single Lecture ... ... **2s. 0d.**

Full particulars may be had free on application to

ROBERT MITCHELL, Director of Education.



NOBEL PRIZE AWARDED FOR ILLUMINATING APPARATUS.

We notice that this year a Nobel Prize was awarded to Mr. Gustaf Dalen for his inventions in connexion with automatic flashlight apparatus.

This apparatus has been described in *The Illuminating Engineer*. The "sun-valve" used with buoys lighted by acetylene causes the light to be turned on automatically when evening comes, and to be extinguished (except for a pilot light) during the daytime. Other automatic apparatus serves to produce flashes at regular intervals, and thereby accomplish a considerable saving of gas, as well as making the device more successful in attracting attention.

These devices have been very largely used in navigation for beacons, buoys, &c., and of late they have also been applied to railway signals.

HOW SUNLIGHT SLAYS CONSUMPTION.

An enterprising development of the crusade against consumption took place on November 27th at the Court Theatre (London) under the auspices of the Women's National Health Association of Ireland and the Women's Imperial Health Association.

An attractive picture-play was organized, in which it was shown how the great white demon (consumption) and his microbes (ignorance, squalor, shut-window &c.), were ultimately overcome by the sun. The great scene was the one in which the sun finally slew the demon. One more illustration of the conviction that one of the most potent means of fighting disease is sunlight. Light and hygiene are very closely connected.

A SHOW-WINDOW CONTEST.

Interesting Scheme in the Tottenham Court Road.

Shop-window contests have frequently been organized in the United States, and it is interesting to note that the tradesmen in the Tottenham Court Road are now entering into friendly rivalry on somewhat similar lines. We understand that the scheme originated from Mr. J. H. Patterson of the National Cash Register Co. A Committee of local tradesmen has been formed, and prizes to the value of £87 have been offered for the best window. It is stated that the windows will be judged by experts from well-known West-End stores, and in awarding prizes the lighting will be one of the points taken into consideration. £50 has been collected for general decorations in the streets.

'PUNCH' ON ILLUMINATION AGAIN.

In a recent issue Mr. Punch draws an amusing picture of the discomforts of the bedroom lighting in a second-rate hotel.

He imagines the guest adopting a sarcastic vein, thus :—

" 'So you read in bed ?' I should say,

" 'Does your doctor not object ? Ah ! well, you don't mind if he does. But for other people's eyes you have more consideration, and that, of course, is why in my room there is no reading-lamp and the light is fixed over the window. It is very solicitous of you.' "

Or breaking into fierce invective :—

" 'Why on earth can't you have the sense to realize that it is as easy to put a bell close to the bed as far from it, and that no one can read with the light opposite, dazzling his eyes. Here, give me the bill and let me find a civilized place !' "

Truly, bad lighting is no longer suffered gladly. An hotel that lights its bedrooms in the way described above inevitably drives away custom.

ELECTRICALLY LIGHTED SPEED SIGNAL FOR TAXIS AND MOTOR-BUSES.

The Home Office and the Scotland Yard authorities are seriously considering a device called the "Farometer" for the prevention of accidents through fast driving. The little machine is decidedly interesting. It is fixed on a prominent part of the car, such as the radiator, and the large numerals, showing the number of miles per hour at which the car is travelling, are easily seen. When the legal limit is exceeded, the driver is warned by a gong sounding ; if he persists in travelling faster, the public are warned by the appearance of a danger flag, which is electrically lit at night-time.

THE IMPORTANCE OF GOOD INDUSTRIAL ILLUMINATION.

(Comments by an Italian Paper.)

A recent number of *Il Lavoro* (Milan) remarks that lighting is destined within a few years to be one of the most important industrial questions. The enthusiasm with which this matter has been taken up in England is extending to the whole world, and the success of the Society in arousing interest in this important question in the short space of three years is quite remarkable.

As a special instance of the need for good lighting *Il Lavoro* mentions printing work ; this includes very delicate operations that cannot be carried out without the aid of adequate illumination.

CLEAN WINDOWS, PLEASE !

Dr. H. H. I. Hitcheon, of Heywood, has been commenting on the value of clean windows in schoolrooms. A correspondent writes to inform us of some tests carried out by him on the windows of a Government office in London. When these were cleaned an improvement of 30 per cent in the desk-illumination was secured.

A common rule in such offices is that windows should be cleaned quarterly at regular intervals. It would probably be better (if more frequent cleaning is not permissible) to arrange for the intervals to be *four* months in summer and *two* months in the dark winter months, when dust tends to accumulate and daylight is naturally least effective.

And it would also be a good plan to make a practice of cleaning the lamps and shades in the room thoroughly at the same time.

Some Examples of Good and Bad Illumination.

The Value of Good Shading in Desk and Table Lighting.

Bad Lighting. The reflector does not completely cover the lamp, which shines into the eyes of the worker.

A better arrangement. The lamp is completely screened by a reflector, which directs the light on the table.

Here again the lamp is not completely screened. It causes glare, shines in the eyes of the draughtsman, and does not direct much of the light downwards.

A better arrangement. The lamp is completely screened by translucent reflector, green on the outside and not trying to the eyes.

Review of the Technical Press.

ILLUMINATION AND PHOTOMETRY.

One of the most interesting articles in this section is that of K. Bunte (*J.f.G.*, Dec. 7), who discusses **Measurement of Illumination in the Streets.** He shows that such measurements should be made in the horizontal plane one meter above the ground, and explains how the illumination can be worked out beforehand once the distribution of light from the lamps to be used is known.

G. Dettmar (*E.T.Z.*, Dec. 5) gives an account of the formation of the German Illuminating Engineering Society; this, it will be recalled, was referred to in our last number.

H. E. Ives contributes an account of some additional experiments on **Colour-Photometry** (*Phil. Mag.*, September). These researches are supplementary to some previously undertaken. He adopts the "critical frequency" method of judging flicker, and finds that the reversal of the Purkinje effect characteristic of the flicker photometer at low illuminations also manifests itself when this method is used. In *The Electrician* reference is made to the possibility of using the selenium cell in photometry. A. H. Pfund has carried out some researches on this point, but reference to his results has already been made in this journal.

The most interesting point brought out by them is the apparent existence of an effect at low illuminations analogous to the Purkinje phenomenon.

Sir William Abney (*Roy. Soc. Proc.*, Aug. 13) describes some interesting experiments showing how the appearance of a small coloured object is affected by a bright white illuminated area adjacent to it.

Good Lighting (*The Illuminating Engineer* of New York) contains several interesting contributions. Perhaps the most important of these is that relating to an Act proposed by the New York State Factories Commission embodying **Legislation on Industrial Lighting.** There is also an illustrated article dealing with **Lighting Fixtures** from the decorative standpoint. It is shown how the four methods of artificial light distribution, on which present designs are based, are derived from the candlestick, the candelabra supported on columns or standards, chandeliers suspended from ceilings, and wall brackets. The illustrations show the changes in these designs from ancient days up to the present time. Another article deals with **Railway Signalling** and the methods of lighting employed therewith.

ELECTRIC LIGHTING.

There is very little to be said regarding this section. C. F. Lorenz (*Elec. World*, N.Y., Nov. 30) deals with the **Stroboscopic Effects** produced by incandescent lamps. It requires a high voltage low candle-power lamp and a frequency of not more than 30 to make these effects perceptible, but they can be accentuated by surrounding the filaments with an inert gas instead of a vacuum.

The same point has recently been investigated by L. Wild (*Jour. Inst. Elec. Engin.*, July), using an ingenious photometric method. Metal filament lamps appear to give a slightly increased candle-power on alternating current, and have a slight leading power-factor.

G. C. Keech (*Elec. Rev.*, N.Y., Nov. 23) gives an account of the **Quartz Tube Mercury Vapour Lamp.** It will be recalled that this lamp has been used for the lighting of some American streets, the method being to suspend it from brackets attached to the walls of the houses.

GAS, OIL, AND ACETYLENE LIGHTING

High-Pressure Gas Lighting comes in for treatment at the hands of W. Grafton (*Gas World*, Dec. 14), who gives some account of the newly installed lighting in Glasgow. He describes the special arrangement made in that city to enable high-pressure gas lamps to be hung centrally, drawn to the side of the road, and lowered to receive attention when necessary. Flexible tubes were originally used, but were found to be unsightly, and specially designed linked piping was subsequently introduced. He finds that the lamps gave 50 to 60 c.-p. per cubic foot. Data are given regarding the renewal of globes and mantles, and

the cost per 1,000 c.-p. hours, taking gas at 1*s.* 6*d.* per thousand cubic feet, is stated to be 0·2*d.*—surely a very low figure. PETSCH (*J.f.G.*, Dec. 14) reviews various devices used in self-intensifying gas lamps. One of the most interesting and recent of these utilizes the pressure of mercury vapour in order to promote an intimate mixture of gas and air.

T. J. LITLE contributes an article on the **Evolution of the American Inverted Incandescent Burner** (*Amer. Gas Light Jour.*, Dec. 2).

He discusses the mechanical construction of the burner, the use of thermostatic control, &c., and shows different types of globes and reflectors. Some of the most compact and effective forms of lamps are those utilizing Holophane reflectors.

A correspondent in the same journal gives an account of the Manchester Street Lighting Tests, and draws some conclusion as to the cost of public lighting by gas and electricity in large towns.

The Gas World contains a summary of the adjourned discussion on Colour Effects of Illumination, which took place at a recent meeting of the London and Southern District Junior Gas Association. The chief point brought out is the need for specifying the colour of the light, as well as that of the surface investigated, when stating the reflecting power of such surfaces.

List of References:—

PHOTOMETRY AND ILLUMINATION.

Abney, Sir W. The Extinction of Light by an Illuminated Retina (Roy. Soc. *Proc.*, Aug. 13).
Boardman, D. Railway Signalling and the Lighting thereof (*Good Lighting*, Nov.).
Bunte, K. Beleuchtungsmessungen auf Strassen (*J.f.G.*, Dec. 7).
Dettmar, G. Bericht über die Grundung der Deutschen Beleuchtungstechnische Gesellschaft (*E.T.Z.*, Dec. 5).

For Shop Lighting.

HIGH CANDLE-POWER

OSRAM

DRAWN WIRE LAMPS

are rapidly displacing every other form of artificial illuminant, Economy, Efficiency, Strength, and Long Life being conspicuous factors in their extraordinary success in this direction.

OSRAMS produce just the light required to display goods to the best advantage—constant, steady, white, and bright—and need no attention whatsoever from first to last.

Write for Particulars and Prices.

THE GENERAL ELECTRIC CO., LTD.,

Head Office:

67, Queen Victoria St., London, E.C.

Editorials. In the Interests of Eyesight (*J.G.L.*, Dec. 19).
Illumination Prospects (*J.G.L.*, Nov. 26).
Selenium in Photometry (*Electrician*, Dec. 6).
Rural Street Lighting Contracts (*Elec. Rev.*, N.Y., Dec. 16).
Colour of Illuminants (*Elec. World*, Oct. 19).
Ives, H. E. The Photometry of Lights of Different Colours (*Phil. Mag.*, Sept.).
Martin, D. S. The 1912 Activities of the Illuminating Engineering Society in America (*Electrician*, Dec. 6).
Pfund, G. H. Application of the Selenium Cell to Photometry (*Electrician*, Dec. 6).
The Illumination of Workshops (*Elec. Rev.*, N.Y., Nov. 30).
Automatic Lighthouses on the Panama Canal (*Illustrated Lond. News*, Dec. 21).
An Act relating to Factory Lighting (*Good Lighting*, Nov.).
Lighting Fixtures as Decoration Accessories (*Good Lighting*, Nov.).

ELECTRIC LIGHTING.

Cooper, M. D. Electric Lighting for Motor Cycles (*Elec. Rev.*, N.Y., Dec. 14).
Editorial. Flat Rates for Tungsten Signs (*Elec. Rev.*, N.Y., Nov. 23).
Fuller, G. E. Electric Signs (*Elec. Rev.*, N.Y., Nov. 23).
Keech, G. C. The Quartz Tube Mercury Vapour Lamp (*Elec. Rev.*, N.Y., Nov. 23).
Lorenz, C. F. Stroboscopic Effects from Incandescent Filaments (*Elec. World*, N.Y., Nov. 30).
Montsinger, V. M. Commercial Tests of Lighting Transformers (*Elec. Rev.*, N.Y., Nov. 30).
Wild, L. The Tungsten Filament Lamp on Alternating Current (*Jour. Inst. Elec. Engin.*, July).

GAS, OIL, AND ACETYLENE LIGHTING.

Elliott, A. H. Effect of Various Diluents on the Candle-power of Oil Gas (*Am. Gaslight Jour.*, Nov. 25).
Grafton, W. High Pressure Lighting in Glasgow (*Gas World*, Dec. 14).
Litle, T. J. Evolution of the American Incandescent Inverted Burner (*Am. Gas Light Jour.*, Dec. 2).
Petsch. Gasstarklicht (*J.f.G.*, Dec. 14).
Strache, H. L'Intluence de la Temperature de Flamme sur l'Intensité lumineuse du Bruleur à Incandescence par le Gaz (*Rev. des Eclairages*, Nov. 1).
High Pressure Gas at Maidstone (*J.G.L.*, Dec. 24).
Gas Lighting and Electric Lighting for Public Streets in Large Towns (*Am. Gas Light Jour.*, Dec. 2).
Colour Effects in Illumination (*Gas World*, Dec. 21).

CONTRACTIONS USED.

E. T. Z.—*Elektrotechnische Zeitschrift.*
G. W.—*Gas World.*
J. f. G.—*Journal für Gasbelewchtung*
J. G. L.—*Journal of Gaslighting.*
Z. f. B.—*Zeitschrift für Beleuchtungswesen.*

Some Publications Received.

Electrical Photometry and Illumination. By Hermann Bohle. (Charles Griffin & Co.)

Competition Points for Gas Salesmen. By Arthur F. Bezant. (Walter King, Office of *The Journal of Gas Lighting*, 1912.)

The Art of Seeing. By An Artist. (Elementary and Practical Hints as to the Perception and Enjoyment of the Beautiful in Nature and in the Fine Arts.) By Andrew Robertson. (Eyre & Spottiswoode, 1898.)

How to know Architecture. By Frank E. Wallis. (Harper & Brothers, New York and London, 1910.)

Electricity for Everybody. Second and revised edition. (Scholey & Co.)

Kalender für das Gas- und Wasserfach. Special Section on Hydraulic Matters by G. Anklam. (R. Oldenbourg, München und Berlin.)

Holophane (U.S.A.): 1913 Suggestions—Illuminating Glassware.

Illumination at the Coal-Face, with Special Reference to the Incidence of Miners' Nystagmus. (A paper read before the South Staffordshire and Warwickshire Institute of Mining Engineers.) By Dr. T. Lister Llewellyn.

The Effects of Deficiency of Oxygen on the Light of a Safety Lamp. (A paper read before the South Staffordshire and Warwickshire Institute of Mining Engineers.) By Dr. J. S. Haldane and Dr. F. Lister Llewellyn.

TRADE NOTES.

[At the request of many of our readers we are extending the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

The Welsbach Showrooms.

(Gray's Inn Road, London, E.C.)

The Welsbach Showrooms were recently visited by a representative of *The Illuminating Engineer.*

There are a number of novel lamps and fixtures to be seen. The ground floor is given over partly to the smaller forms of burners and shades, but the room devoted to the larger lamps is, perhaps, the most interesting. The high candle-power low-pressure lamps in particular deserve some reference. These are made in three sizes, rated at 300, 600, and 1,000 candle-power respectively, and consuming 7½, 15, and 25 cubic feet of gas per hour. The lamps are stated to give 40 candle-power per cubic foot of gas consumed, and it was pointed out that these values are *mean hemispherical.* There has been some discussion in this country lately as to how the light from gas lamps should be rated. In Germany values are given usually in M. Hem. Sph. Candle-power. This method has much to recommend it, as it takes into account all the light thrown in a downward direction. Welsbach high-pressure air-lamps are also to be seen. The high-pressure air-system has not been much used in Great Britain, but there are certain precautions necessary (which have not always been observed) to make high-pressure air-lamps a success. One of them is the need for a good gas-governing arrangement, such as is fitted into the Welsbach lamps. The nature of the governor may not be so very vital in the case of low pressure; but when a high-pressure air-supply is connected, a good method of governing is much more important, as a slight irregularity in the pressure at once affects the working of the lamps.

There are certain advantages claimed for high-pressure air as compared with high-pressure gas systems. These have been the subject of reference in this journal on several occasions. One instance of the convenience of high-pressure air, not previously mentioned, is furnished by the mining districts in the Midlands. It appears that in some of these places the branching galleries of the mines underneath the soil lead to a tendency for the earth to settle, which is apt to cause trouble in the case of pipes laid underground. On the other hand, there are objections to running high-pressure mains above the ground. These objections, however, do not apply in the same way to pipes conveying *high-pressure air.*

Another novelty to be seen in the Welsbach Showrooms is the semi-indirect gas unit. Some of these are made up in a manner closely resembling forms of electric fixtures. The method is quite familiar in Germany; but, curiously enough, it has only recently been introduced into this country. There seems no reason why it should not be much more widely used with gas, seeing that it is proving so popular in the case of electricity.

We propose to deal with some of these novelties in a separate article which will probably appear in our next number.

"Osrams" on the Jungfrau Railway, Switzerland.

The highest railway station in the world (3,475 metres) has recently been equipped with Osram Drawn-Wire Lamps.

The authorities of the Jungfrau Railway, in Eigergletscher, Switzerland, have also equipped several trains with Osram Lamps, as well as their station Eismeer; they have reported the Osram Lamp as satisfactory in every way.

The extreme vibrations and jolts which the Osram Lamp is subjected to in this railway service can be readily imagined, and the fact of the lamps giving satisfaction under these conditions says much for their strength and durability.

The British Westinghouse Company's Supply Showrooms in Manchester.

The British Westinghouse Company's Supply Department have recently opened new offices and showrooms at 14, Long Millgate, Manchester. The accompanying illustrations show some of the demonstration rooms.

The basement is of considerable extent, and is utilized for storage purposes and for packing. On the ground floor are the sales depôt and despatching department. The shop is handsomely finished, and a stock of everything electrical in the way of supplies at hand, so that prompt and immediate attention can be given to purchasers who are in need of large or small quantities of accessories. An elaborate window display includes the well-known Westinghouse-Auriga drawn-wire lamps, Auriga-Holophane glassware in various shapes and sizes, electric light fittings, stoves and heaters, electric irons, cookers, and so forth.

The first floor of the Westinghouse Supply Department premises is given over to well-arranged and completely equipped showrooms for the convenience of contractors. The main showroom is hung with a great variety of fittings, including Benjamin steel reflectors, Auriga-Holophane globes and fixtures suitable for large halls, hotel lounges, drawing-rooms, and the like. The fittings are spaced out in such a manner that each can be lighted separately, and the individual effect of each may be judged without the view being obstructed, as is so often the case, by a veritable forest of other pendants. Any fitting can be taken from the main showroom and hung and lit at a moment's notice in the model drawing-room and dining-room (to judge as to the effect), which is provided especially for this purpose. On the walls are provided the different types of wall brackets, also capable of being individually lighted. Two large show-cases in the middle of the room contain table lamps of different designs, a very handsome selection of china vase type table lamps with hand-painted silk shades. Round the walls are ranged show-cases containing various switches, adapters, insulators, &c. Radiators and stoves are placed on the floor, each being connected up for immediate lighting. On the dining-room table are laid various types of cookers and heaters, including the Westinghouse electric toaster stove.

The second floor contains the Supply Department offices and extensive stock-room for electric accessories. The third floor is the lamp store, where large stocks of all types and sizes of Auriga drawn-wire lamps are stored. On the fourth floor is the glassware store.

One can quite understand that these showrooms will be a great boon to local electrical contractors, since every electrical accessory is obtainable there at the shortest notice.

The New B.T.H. Lamp and Wiring Supplies Catalogue.

We have received from the **British Thomson-Houston Co.** a copy of the first bound Catalogue issued by the Lamp and Wiring Supplies Department of Mazda House, 77, Upper Thames Street, E.C. The Company may be congratulated on this 400-page Catalogue, the compilation of which, we understand, was accomplished within three months.

The general get-up and printing are distinctly good, and the system of indexing and cross-indexing make it possible to find any section quite easily.

The section of chief interest to readers of this Journal is naturally that dealing with illumination. This contains illustrations and data of the well-known B.T.H. indirect and semi-indirect fittings: the Veluria, Mazdalux, and X-ray reflectors, and the new types of Mazdalier and Tungstalier fittings. This section contains a concise illustrated article dealing with illumination in general, and containing some suggestions as to how these various types of fittings could be used.

The final section deals with arc lamps (including the B.T.H. Magnetite lamp), radiators, cooking apparatus, small motors, ventilating fans, &c.

Two views of the British Westinghouse Company's Showrooms at Millgate, Manchester.

Chinese Advertisement for Osrams.

One result of the opening up of Eastern countries has been an increased demand for artificial light, and a brisk trade in lighting appliances has already developed.

Now trading conditions in China demand a style of advertising different from our own. The Chinese cannot be interested in literature unless it is prepared in their own particular style. This is the experience of the General Electric Co., Ltd., after an experience in connexion with Osram Lamps, and circulars and pamphlets regarding Osram Lamps are now drawn up in characteristic Chinese style. These have already been productive of excellent results.

A specimen of Osram Chinese literature is shown.

12. 1. 12.

A New Microscope Lamp.

Prof. B. E. Roberts of Cardiff recently designed a lamp especially adapted to microscopic observations. Realizing the

value of this lamp to institutes, hospitals, and schools, the **General Electric Co., Ltd.**, has undertaken the manufacture, and is now placing this particularly useful little lamp upon the market. The demand already experienced is apparently a very clear indication of the need existing for this type of lamp fitting. We understand that it is now being used in the new Pathological Institute, Cardiff, with satisfactory results.

The brass foot is heavily weighted and covered with baize underneath, the upright portion is brass tubing bent to accommodate the lamp itself; at the top is a knuckle joint, by which the lamp can be adjusted to any required angle. The parabolic shade is of nickel-plated metal. The source of light is an Osram lamp, frosted below.

The most recently issued list of electrical novelties issued by **G. Braulik** (Lambeth Hill, Queen Victoria Street, E.C.) contains quite a striking variety of handy little accessories. These include electric pocket lamps and torches, scarf-pins, miniature dynamos and motors, telephones, and "Eclipse" lamps.

The ILLUMINATING ENGINEER
ELECTRICITY · ACETYLENE · OIL · GAS
Edited by LEON GASTER

THE JOURNAL OF SCIENTIFIC
ILLUMINATION.
OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London, 1909.)

ILLUMINATING ENGINEERING PUBLISHING COMPANY, LTD.
PUBLISHING OFFICES :—ATHENÆUM PRESS, 13, BREAM'S BUILDINGS, LONDON, E.C.
Tel. No. 2120 Central.
EDITORIAL OFFICES :—32, VICTORIA STREET, LONDON, S.W.
Tel. No. 5215 Victoria.

EDITORIAL.

The British Departmental Committee on Industrial Illumination.

As announced elsewhere in this number, the Home Secretary has appointed a Committee to "enquire and report as to the conditions necessary for the adequate lighting (natural and artificial) of factories and workshops, having regard to the nature of the work carried on, the protection of the eyesight of the persons employed, and the various forms of illumination." The formation of this Committee was foreshadowed in the last Report of H.M. Chief Inspector of Factories, and referred to in *The Illuminating Engineer* some time ago. Those interested in the movement will recognize that a great and important step has been taken.

The initiative in appointing a Committee to deal with illumination was taken by France last year, and we understand that valuable data have already been collected. The writer, in the course of his recent visit to Paris, had the opportunity of seeing its Chairman (M. Gariel), from whom he received assurances of the desire of the Committee to co-operate with other countries. The Hon. Secretary (Dr. Motais) has since been making overtures for the formation of similar Committees in other countries, and we hope that before long all the chief nations of the world will be taking part in this work.

Meantime we trust that the efforts of the two Committees already in existence will be of mutual assistance. Ultimately the data collected in the various countries might be assembled and presented at an international congress on illuminating engineering. This would pave the way for some general world-wide recommendations as regards standards of illumination.

We trust that when the time is ripe the initiative of calling an International Congress on Illumination will be taken by this country, which has already made valuable investigations on factory lighting (Mr. D. R. Wilson's researches, embodied in the last Report on Factory Lighting, may be singled out for special mention), and is admirably fitted to act as a connecting link between the Continent and the United States.

Acetylene and Petrol - Air Gas.

The meeting of the Illuminating Engineering Society on January 14th, at which papers on the above subjects were read by Mr. E. Scott-Snell and Mr. C. Hoddle, was very well attended.

In the two papers illumination-data were presented of a kind not often furnished for these illuminants. In the case of gas and electric lighting there are now simple rules by the aid of which one can calculate with a fair certainty how much energy is required to produce a given illumination on the working plane. Mr. Hoddle and Mr. Scott-Snell have made an attempt to draft similar data for use with acetylene and petrol-air gas. The illumination data were accompanied by photographs taken entirely by artificial light, in the same way as has been done at other meetings of the Society.

We confess we should like to have heard something more regarding the *use* of petrol-air gas and the circumstances in which it can best be employed. There seems an opening for the development of the Illuminating Engineering side of petrol-air gas lighting. The time is coming when the provision of a certain definite illumination will be required for industrial purposes, and a variety of burners and reflectors, making possible a wide range of candle-power and varying the distribution of light, will then be essential. At present the range of units available for petrol-air gas lighting seems limited in comparison with gas or electricity, and this has, perhaps, helped to foster the impression that its scope is somewhat restricted.

In Mr. Hoddle's paper the special uses of acetylene were dealt with more fully. Acetylene lighting is particularly interesting in this respect, and its special applications for emergency illumination, motor-car lighting, navigation, &c., alone should provide food for a good discussion.

Mr. Darch raised the question as to the resemblance of acetylene to daylight. Claims to this effect are often made, and we

ourselves would like to hear more detailed, scientific evidence in support of the cry of "nearest to daylight" so frequently raised. This claim likewise occurs in much of the petrol-air gas literature, and it has also been made on behalf of the electric arc light, the Moore carbon dioxide tube, and a number of electric lamps using special daylight-screens. One would like to see the degree of resemblance of all these illuminants to daylight more thoroughly investigated, both in the laboratory and in actual practice in the hands of colour-matching experts.

The Lighting of Engineering Workshops.

On pp. 99–105 we give a brief summary of the papers on the above subject recently read by Mr. Haydn T. Harrison, Mr. Franklin Thorp, and Mr. G. E. Evered before the Manchester Association of Engineers. It was a decidedly enterprising step to invite exponents of gas, oil, and electric lighting to present papers on the same evening, and we understand that the meeting was a most successful one. Certainly but a few years ago a friendly discussion on these lines (even if the representatives of the various systems could have been induced to appear on the same platform) would have been considered quite impracticable. This appears to us the right method of presenting comparative data—to afford an opportunity for each representative to present the case for his own illuminant without attacking others.

It will be observed that, while the three papers naturally deal mainly with the use of the respective illuminants, there is in each a substratum of common ground. All agree in emphasizing the value of good lighting to the manufacturer. In order to provide a certain common basis, the authors were also asked to suggest a method of lighting a machine shop of specified dimensions. No definite prescription was made as to the illumination in foot-candles to be provided on the working plane or on the bench, and the absence might have made comparisons between the papers somewhat difficult. Fortunately the authors recognized the importance of such an omission, and took care to specify the illumination provided as well as the running cost of the system.

We have often argued that the provision of a certain illumination on the working plane forms the best basis of comparing different systems of lighting. The tendency at the present time is strongly in favour of this method, which really goes to the root of the matter and secures that the consumer shall get what he actually needs—sufficient light on the spot where the work is actually carried out. The number of illumination-photometers recently introduced in this country is evidence that this impression is gaining ground, and illumination is a commodity that can

now be measured with quite sufficient accuracy for commercial purposes.

Demonstrating the Value of Good Illumination to Non-Technical People

The problem of impressing people not actually engaged in some branch of the lighting industry with the necessity for good illumination is one that often confronts the lighting engineer. Demonstrations with a simple form of illumination photometer, succinct and comprehensible figures as regards cost, photographs of good installations taken by artificial light—all these are useful. But something more is needed.

There is no doubt that model installations—actual examples of good and bad systems—often make a strong impression. It is nearly always easier to appeal to the *eye* than to the ear, and a demonstration will often effect what a lengthy conversation would not. Such model installations and, the exhibition of the correct and faulty systems side by side, should form a feature at any exhibition of lighting appliances, and it is surprising how little has yet been done in this way. For lectures models on a small scale would often be useful. The ingenious method adopted in a recent lecture in the United States by Mr. Preston Millar, who has equipped small boxes with small furniture, miniature lighting units, and even dolls, to represent the correct and faulty positions for reading, &c., is worthy of study.

In appealing to the manufacturer the method suggested by Mr. Thurston Kent, and recently referred to in these columns,* of noting the time taken by industrial operations before and after the improved lighting has been introduced, seems to have great possibilities, although it is not every consulting engineer who would be granted facilities to make such tests. But when all is said and done, actual instances of improved output and saving in labour achieved by good lighting are what are really needed. Many manufacturers could, if they would, furnish valuable figures. The trouble is that, having once made a change and proved its special serviceability for their class of work, they are not unnaturally somewhat disinclined to publish the facts for the benefit of their competitors.

It is possible that many of our readers are in a position to relate instances of this kind that have come under their notice. We should be very glad to give publicity to interesting information of this description, which might be of considerable service to the lighting industry at the present moment. LEON GASTER.

* *Illum. Eng.* Lond., Sept., 1912.

TRANSACTIONS
OF
The Illuminating Engineering Society
(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

Acetylene and Petrol Air-Gas Lighting.

A MEETING of the Society was held at the house of the Royal Society of Arts at 8 P.M. on Tuesday, January 14th, the chair being taken by MR. R. J. WALLIS-JONES.

The minutes of the last meeting having been taken as read, the names of applicants for membership were announced in the usual way, and the Chairman then called upon MR. C. HODDLE to read his paper on 'Acetylene Lighting.' The paper was illustrated by a number of interesting slides, including photographs of natural colours and a variety of flowers. At the conclusion MR. HODDLE showed a series of interesting exhibits, including a new form of oxy-acetylene lamp for cinematograph purposes, the "Dalen" sun valve, a new form of flash-light signalling apparatus for army purposes, &c.

Subsequently MR. E. SCOTT-SNELL read a paper on 'Petrol Air-Gas Lighting,' and exhibited a plant in actual operation. A discussion on the papers ensued, in which the following took part: MR. CHARLES P. BLATCHLEY, MR. W. J. A. BUTTERFIELD, MR. R. W. A. BREWER, MR. DONNITHORNE, MR. W. J. LIBERTY, MR. R. J. PINNOCK, and MR. F. S. THORN.

In conclusion, THE CHAIRMAN moved a vote of thanks to the lecturers and to those who had contributed to the success of the evening by exhibiting apparatus, and the vote was carried by acclamation.

The next meeting of the Society was announced to take place on **Tuesday, February 18th,** when a paper dealing with the **Use of Globes, Shades, and Reflectors** will be read by MESSRS. J. G. CLARK and V. H. MACKINNEY.

ANNUAL DINNER, February 10th, 1913.

The Council have decided to hold the **Annual Dinner** during the present year on **Monday, February 10th,** and it is hoped that this will be the means of bringing together those interested in the aims and objects of the Society. The Chair will be taken by **The President, Professor S. P. Thompson, D.Sc., F.R.S.,** and it is anticipated that a number of distinguished guests will be present. It is earnestly hoped that members will make a special effort to be present on this occasion, and that they will bring with them, as guests, several friends whose sympathy and support would be of value to the Society.

The Dinner will be held at the **Trocadero Restaurant,** Piccadilly, London, W., and the price of tickets will be **10s. 6d.** (exclusive of wine).

Applications for tickets should be addressed to the **Hon. Secretary, Mr. L. Gaster, 32, Victoria Street, London, S.W.,** preferably not later than Thursday, February 6th.

New Members of the Society.

At the meeting on January 14th the names of applicants for membership read out at the previous meeting on December 3rd were formally announced for the second time, and these gentlemen were declared Members of the Illuminating Engineering Society.*

In addition, the names of the following gentlemen have been duly submitted and approved by the Council, and were read out by the Hon. Secretary :—

Ordinary Members.

Arnold, W. F.	The General Electric Co., Ltd., 71, Queen Victoria Street, London, E.C.
Asdell, J. H., *M.Sc.*	Lighting Engineer, 29, Mostyn Road, Handsworth, Staffs.
Blatchley, C. P. *B.A. Oxon.,F.C.S.*	Managing Director of the County Light Co., Ltd., 13, Templars Avenue, Golders Green, London, N.W.
Crush, F.	54, The Avenue, Bedford Park, London, W.
Davis, S.	Publisher and Advertising Contractor, 1, Army and Navy Mansions, Victoria Street, London, S.W.
Ellis, S. T.	Electrical Engineer, 54, Saltwell Road, Gateshead-on-Tyne.
Freeth, T. C.	Electrical Engineer, 38, Bishops Mansions, Fulham Road, London, S.W.
Hale, F. H.	Electrical Engineer, Warrenhurst, London Road, Bromley, Kent.
Howling, W. H.	Designer, 12, King's Road, Wimbledon, Surrey.
Humphrey, G. W.	Electrical Engineer, 10, Victoria Avenue, Canton, Cardiff.
Jones, J. H.	Designer, 29, Lorne Road, Stroud Green, Hornsey, London, N.
Kann, E. A.	The General Electric Co., Ltd., 67, Queen Victoria Street, London, E.C.
Lakin-Smith, C.	Engineer, County Engineering and Lighting Co., Ltd., &c., 10, Colonnade, New Street, Birmingham.
Matthews, R. Borlase, *Wh.Ex., M.I.E.E., A.M.I.C.E.*	Electrical Engineer, Midland Bank Chambers, 71A, Queen Victoria Street, London, E.C.
Mayes, F.	Hope Villa, Linton Road, Barking, Essex.
Robertson, C. E.	254, Albion Road, Clissold Park, London, N.
Ross, P.	Electrical Engineer, 17, Gresham Street, Liverpool.
Shaw, F.	Advertising Manager to the British Thomson-Houston Co., 21, Merlin Road, Manor Park, Essex.
Stevenson, J.	Secretary to the British Graetzin Light, Ltd. (Westminster), 51, Haslemere Road, Thornton Heath.
Sutton, E. A.	129, Grosvenor Road, Highbury, London, N.
Trippe, C. F.	Electrical Engineer, Avalon, Pyrford, Surrey.
Watson, J. F., *M.I.C.E., M.I.M.E.*	Consulting Engineer, Sun Buildings, Park Road, Leeds.

Corresponding Member.

MacMurtrie, F. C.	General Editor for the American Association for the Conservation of Vision. 1, Madison Avenue (Metropolitan Bridge), New York.

* *Illum. Eng.*, Jan., 1913, p. 18.

Acetylene Lighting.

By C. Hoddle.

(Paper presented at a meeting of the Illuminating Engineering Society, held at the House of the Royal Society of Arts, John Street, Adelphi, London, on Tuesday, Jan. 14th).

[Abstract.—The author gives a brief account of the generation of acetylene, the burners commonly used, and the cost of lighting an average country house. Some photographs of a drawing-room lighted by acetylene, and the exterior of a house illuminated by acetylene flares are also reproduced. Subsequently he refers to the use of dissolved acetylene, and to the use of the gas for country stations, illuminating constructional work by night, for buoys and beacons, &c. Finally he gives the results of some tests on a new projector-lamp, using an oxy-acetylene flame impinging on a disc of ceria.]

Early in November, 1895, the author was reading the morning paper, and noticed an article headed 'A Jug Full of Gas, Please.' This proved to be a short comment upon a paper which had been read by Prof. Vivian Lewes on 'Acetylene,' in which he had mentioned the fact that acetylene gas could be compressed to a liquid at 700 lb. pressure per square inch. The paper (not Prof. Lewes) went on to picture a little girl going to the nearest chandlery shop for a "Jug o' gas," which was to be put into a receptacle connected to the ordinary gas main and used for lighting the house.

This, of course, was rather far-fetched, but it had the effect of inducing the author to obtain and read the original paper, in which he heard of the wonders of acetylene: "A beautiful, pure white light the size of a sixpence, giving 25 c.-p., and consuming only ½ cubic foot of gas per hour." Little wonder that in 1895 this was regarded somewhat as a fairy tale. However, the writer determined to learn more. How he first obtained a few pounds of calcium carbide (after scouring London), at 2*s.* 6*d.* per pound, and my first experiments at generator making, is too long a story to be entered into now, and would hardly prove interesting either, because the early history of acetylene is so well known. Let us, therefore, proceed to more recent developments and present-day uses.

The Production of Acetylene.

As you are aware, the first requisite in connexion with the making of acetylene is calcium carbide, which is manufactured from lime and carbon fused together in an electrical furnace. Although familiar with this for some seventeen years, it was not until last June that the author got an opportunity of seeing carbide in the making during a recent tour in the States, where he went over one of the largest works in America. It is most remarkable how two substances like carbon and lime, which have no affinity for each other in ordinary circumstances, nevertheless combine together at the high temperature of the electric furnace. In order to generate acetylene, all that is necessary is to bring calcium carbide and water in contact with each other, when the following reaction occurs:—

$$CaC_2 + H_2O = CaO + C_2H_2$$

calcium carbide, water = lime, acetylene.

In the generator used to produce acetylene either one of two methods may be followed. Calcium carbide may be placed in water, or water poured on to calcium carbide. One may well be surprised at the number of different ways of performing this simple operation that have been patented during the last ten years.

During 1896 and 1897 the author invented and patented three different kinds of generators: one, carbide to water, primarily intended for optical lantern use; and one, water to carbide, intended for house lighting and similar installations; and one on the water displacement principle, intended for bicycle, hand-lamp, and other portable uses. Photographs and drawings of

these early generators, are now in the South Kensington Museum, and can be seen in the Educational Department.

Acetylene, as it first leaves the generator, is not suitable for house lighting purposes, as it contains a small percentage of phosphoretted and sulphuretted hydrogen. In generators that wash the gas the sulphur is sufficiently removed by the water; but a separate purifying apparatus is necessary to remove the phosphorus, otherwise it will pass through the flame and cause a smoky haze in the room. Such impurities cause an objectionable smell, and, according to some authorities, also lead to choking up of the burner. The author can lay claim to having been almost the first to discover this; in any case, at the Acetylene Exhibition held at the Imperial Institute in 1898 his Company was the only firm to show and use a purifier; he well remembers the sarcastic remarks of competitors regarding it.

A typical modern Acetylene generator is shown in Fig. 1.

One point in connexion with the storage of carbide may be noted. Large quantities are invariably stored in sealed tins, as the effect of moist air in contact with carbide would naturally be to cause a slow liberation of acetylene and gradual deterioration of the material.

Recently the plan has been adopted of compressing carbide into "briquettes," which are coated with some material rendering them inactive to air. This special carbide has been used to some extent in connexion with motor-car headlights and table lamps, as it has the quality of preventing "after-gassing" (*i.e.*, the gradual liberation of acetylene after the tap has been turned off). But its cost is, roughly, four times that of ordinary carbide, and its use is therefore restricted to special purposes, such as those named above.

Fig. 2.—Bray Elta Twin Burner (has five jets impinging on one another).

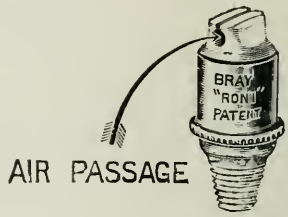


Fig. 3.—Roni Burner (with slot).

Acetylene Burners.

A very important accessory in connexion with the successful use of acetylene for lighting purposes is the burner. In the early days there were no suitable ones to be obtained. Bray's 0000 or 00000 (very small coal-gas burners) were all that could be obtained, and house lighting was almost impossible until the advent of the Naphey burner in 1897, since when the crop of different patterns has been almost, if not quite, as numerous as has been the case with generators; but to-day there are many good ones on the market. Two typical varieties are the Bray Elta and Ota, used mainly for house lighting; and the Roni, mainly for motor and portable lamps.

The Elta utilizes two burners with flames impinging on one another, each burner having two very fine holes. The cross-jet principle is very widely used in modern acetylene burners as it leads to a distinct gain in efficiency; moreover, if one of the burners becomes slightly choked up, the other will continue to give its full value. On the other hand, if one burner is partly stopped up, the other flame may tend to shoot out somewhat. Consequently, this type of burner is not much used for motor-car headlights, &c., having lenses and mirrors quite near to the flame, and the

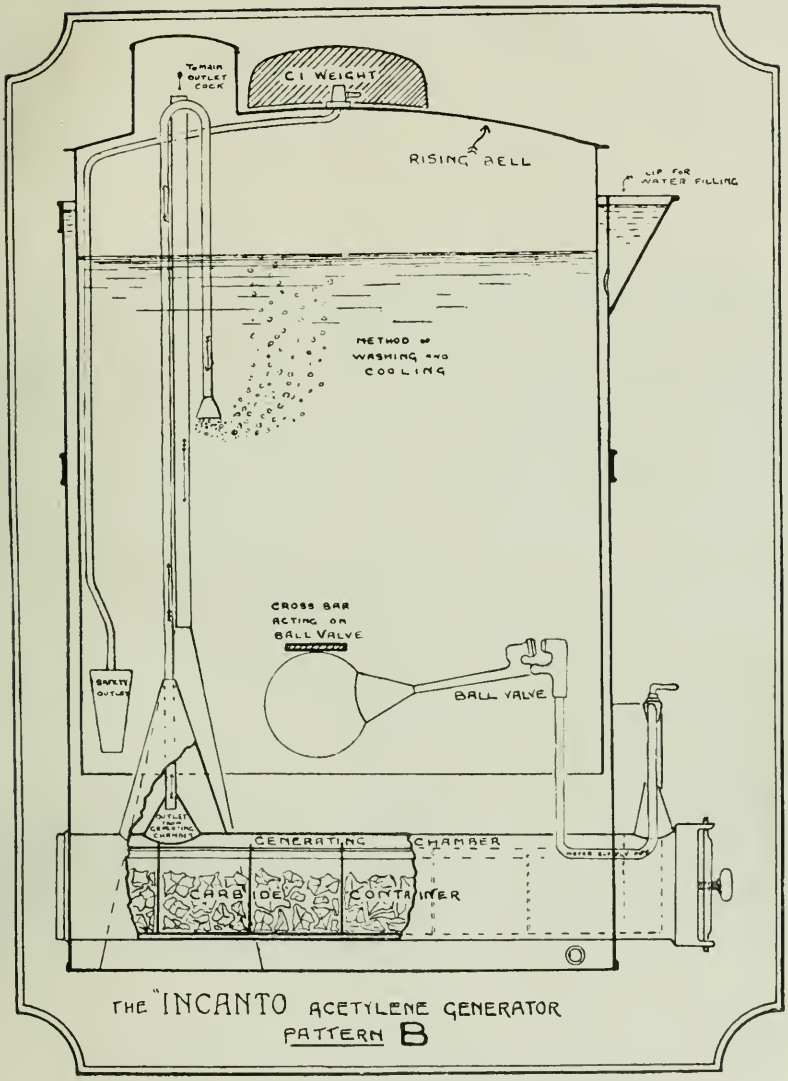


FIG. 1.—Typical Acetylene Generator.

The sectional illustration of B pattern generator shows the simplicity of the "Incanto" system.

The action of generating acetylene is as follows. The carbide containers are about two-thirds filled with carbide, the front plates made tight, and the outer tank filled with water. The front taps are then turned on; gas is now generated and passes into the gas bell, raising it until the ball valve closes, and generation stops automatically until some gas is used. When the bell sinks the same operation is repeated.

Roni type is here preferred. This consists of a single burner having a slot instead of pin-holes. There is no danger of this comparatively large aperture becoming stopped up, and no risk of cracking adjacent glass surfaces.

Acetylene burners should, with proper treatment, last a very long time. The author recalls a house in which many of them have been used for seven years, and are still doing good service. The range of consumption ordinarily employed varies from $\frac{1}{8}$ to 1 cubic foot, the corresponding candle-power being about 10–50. The pressure recommended is usually about 4 in. (water), and in all good acetylene appliances measures are taken to secure that this is practically constant.

As showing the present extent of the industry, it may here be mentioned that Messrs. Bray & Co., of Leeds, alone employ upwards of 500 hands making acetylene burners only, and use some 50 tons of carbide in testing them.

Personally, the author does not favour the use of incandescent mantles with acetylene; he has tried almost every make, but up to now has not found a really reliable one. Like the ordinary burner, the gas orifice is so small that, sooner or later, a bit of grit or dust will partially choke it, and the correct Bunsen flame is upset, the mantle becomes a black mass, and then—well, the less said the better. But, really, Why do we require mantles at all? We have already a splendid pure white light, which we consider to resemble daylight very closely, and we can obtain about 40 c.-p. for a consumption of 1 cubic foot of gas per hour which means (at the present price of calcium carbide, 13*s.* 6*d.* per cwt.), approximately 7*d.* per 1,000 candle-hours. The light is quite constant, and can be used, if necessary, in burners giving only 10 c.-p. In an ordinary house-lighting-installation we use burners ranging from $\frac{1}{8}$ cubic foot to 1 cubic foot, according to position; but the burner most generally in use, and most certainly the favourite, is

(*Photo. taken entirely by artificial light.*)

FIG. 4.—Drawing-room lighted by Acetylene. The central chandelier lights, and the imitation candles round the side of the room, consume together about 3 cubic feet per hour. The illumination is about 1 foot-candle.

that taking ½ cubic foot per hour. This is generally considered the standard.

We can also turn the lights up or down, and regulate the illumination much more perfectly than is possible when mantles are used. We can readily utilize switches for controlling the lights from a distance. The device employed is a press button stop-cock, which turns off all but a glimmer of light, which is kept burning continuously. This enables a person entering a room to turn on the full light at once, whilst the pilot lights are enough to make the position of the switch and surroundings just visible.

Illumination Data.

A few weeks ago some photographs were taken at the author's house entirely by acetylene light (see figs. 4 and 5). The outdoor ones and the snapshots, are somewhat under-exposed, but the one of the drawing-room shows excellent detail. This room is fitted with rather an extravagant amount of light, viz., 140 c.-p., equivalent to 3 cubic feet per hour consumption. We seldom use more than half this, but for the photograph we used the whole. On the settee in the centre and on the walls the illumination was measured and found to be just about 1 foot-candle. The

FIG. 5.—Illustrating the use of acetylene flares for spectacular effect. This house was illuminated at night time by three such flares, each placed at a distance of about 40 feet. The photograph was taken entirely by the acetylene light.

size of the room was 24 ft.×18 ft.; therefore, we get the simple rule that approximately 50 candle-power (1 cubic foot consumption) per 150 square feet floor-space is required; but, as stated, half this is sufficient for ordinary use, so that in estimating the amount of light required for a room of

FIG. 6.—Acetylene flare light and generator, as used for the illumination of the house shown in Fig. 5.

a certain size, 30 c.-p. for 100 square feet floor-space, costing about ½*d.* per hour, would usually be quite sufficient.

Country House Lighting.

At this point it may be of interest to give some details as to the cost of lighting an average country house by acetylene, assuming that such a house requires fifty lights, giving a total candle-power of about 1,000 with two-thirds of the lights on (as is usually the case); in these circumstances the running cost would amount to about 7*d.* per hour. If the majority of the lights are used on an average three hours per night, the cost of carbide per year would be about £30. The total cost of installation, including general average fittings, piping, and everything, should not be more than £100. The generator installed in a moderately big house of this kind would probably be of the twin type, which enables one section of the generator to be used while the other is being re-charged. The charge in the two generators would keep the lights going for eight hours (assuming, as before, that only two-thirds of the lights are going at once).

A word or two may also be said about the lighting effects shown in the outdoor photograph (Fig. 5). The illumination was produced by three portable flare lamps (see Fig. 6) playing upon the house from a distance of about 40 ft. Lamps of this kind, when fully charged, will burn for six hours, consuming 12 lbs. of carbide in doing so. They are estimated to give a light of approximately 1,000 c.-p., and some measurements made on the night in question showed that this estimate was not far out. Lamps of this kind have very frequently been used for garden parties, fêtes, &c. (*e.g.*, to enable bowls to be played by night). As a rough rule one would require four flares of this type, to illuminate every 1,000 square feet.

Resemblance of Acetylene to Daylight.

There are qualities in acetylene lighting which make it specially serviceable for certain purposes. I may refer, firstly, to its pure white colour, which, it has been shown, approaches very closely to that of daylight.

Some tests of colour discrimination by artificial light were described before this Society early in last year, but acetylene was not included among the illuminants studied. On that occasion a picture was shown painted partly by daylight and partly by the light of an arc lamp. The author has in his possession several oil paintings executed entirely by acetylene light, and others done partly by acetylene and partly by daylight, and has often had an opportunity of hearing the views of artists as to the resemblance of acetylene light to daylight. There is no doubt that this resemblance is very close, and he recalls a picture gallery in which acetylene lighting was successfully used.

Acetylene is a very convenient illuminant for lighting greenhouses and conservatories where several shades of colours of flowers have to be revealed. The author has a large collection of

lantern slides of flower-photographs taken entirely by acetylene light. (A number of these were exhibited at the meeting.) Acetylene is perfectly

FIG. 7.—Snap-shot of the author and friend, taken by the light of an acetylene flare.

clean, and does not discolour walls and ceilings; even delicate decorations are not affected by it.

Safety.

As regards safety, it may be said that no artificial illuminant could well be safer; an explosion cannot take place with less than 3 per cent acetylene, which would mean that in a small room of, say, 10 ft. × 10 ft. × 10 ft., or 1,000 cubic feet air-space, 30 cubic feet of acetylene would be required to get an explosion. In other words, a 1-ft. burner (which would be ample to light such a room) would have to be left full on for thirty hours to get an explosive mixture, even if the room was sealed airtight; in the meantime the smell would become unbearable. Of course, accidents have occurred, but one would probably be correct in saying that nearly every one has been caused by amateur-made plants and compopipe installations. (In this connexion the author showed a unique lantern-slide of a large generator which had been on fire. Although the house it was installed to light, and the shed containing the plant were burnt down (through no fault of acetylene), no explosion took place, and after the fire it was found that the generator would work and make gas, although parts of it were entirely burnt away.)

Intrinsic Brilliancy.

Safety in illuminant is certainly an important matter. But there is another point that should appeal strongly to members of the Illuminating Engineering Society, and that is the effect of light on eyesight. A great deal has been written on this subject recently, and no doubt many of the claims made for various illuminants need fuller investigation.

But it will be admitted that acetylene is in a fortunate position in this respect. The tendency for some years has been to make lights more and more brilliant and glaring, and, therefore, methods of shading are in many cases absolutely essential. But the acetylene flame has only a mild luminosity, so that it can be gazed at without the eye being conscious of any discomfort. This is one reason why the light has proved to be very serviceable for fine work, embroidery, &c., and its whiteness is also an advantage when delicate shades of colour have to be distinguished.

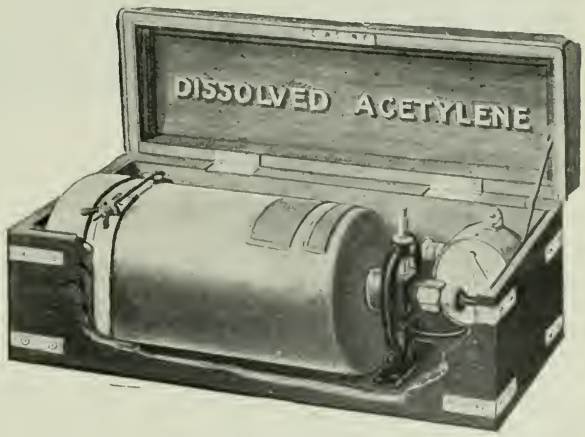


FIG. 8.—Typical dissolved acetylene outfit (suitable for motor-cars, &c.).

Dissolved Acetylene.

Something may next be said on the subject of dissolved acetylene.

Dissolved acetylene has been rendered

possible mainly by the use of the liquid acetone which, at a pressure of 10 atmospheres, and at a temperature of 15 degs., can absorb as much as 240 times its own volume. Now, when this pressure is released by opening a vessel saturated with acetylene in this way, the gas is evolved, because the liquid cannot absorb nearly so much at ordinary atmospheric pressure.

It may be of interest to mention that a new process of dissolving acetylene has recently been announced, although very little is known of its practical utility as yet. The system involves the use of charcoal made by the combustion of blood, and it is said that this new material will absorb as much as 100 times its own volume of acetylene at a pressure of 1 atmosphere only.

Dissolved acetylene outfits are put together in a very convenient and portable form. The smallest size of cylinder in general use will store about 6 cubic feet of acetylene, the cylinder being about 1 ft. long and 4 in. in diameter. Larger cylinders with a capacity up to 100 cubic feet are available.

The advantages of dissolved acetylene lighting are its convenience, and the fact that tubes containing dissolved acetylene can be so readily carried about from place to place, and turned on at any time. Hence they have been used for lantern work, for lighting motor-cars, and, to some extent, for train lighting, &c., as well as their primary use in connexion with welding. Trains in the United States have been run for very long distances with acetylene lighting, charged tubes being stocked at various stations on the way, so as to be replaced for those exhausted while they are being refilled. The same principle has been used in connexion with motor-cars and motor-'buses. In France dissolved acetylene has occasionally been used in emergencies for special festival lighting in churches, the cylinders being connected to extra piping round the altars, &c., which can be readily removed when the ceremony is over.

FIG. 9.—Brockenhurst Railway Station. The lighting, including platform lamps and signals, is acetylene throughout, 200 burners with a total candle-power of 9,000 being installed.

Naturally dissolved acetylene is more expensive than gas produced from a generator in the ordinary way, costing, in fact, about five times as much to the ordinary consumer, and this restricts its use for general purposes.

Advantages of a self contained and Portable System of Lighting.

Another great advantage of acetylene is its self-contained and portable nature. This advantage comes out

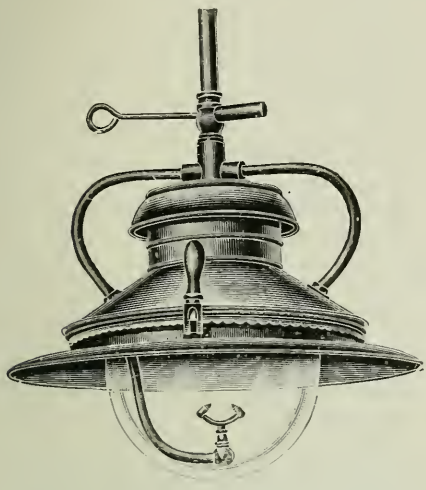


FIG. 10.—Outdoor acetylene lamp, consuming 1 cub. ft. of gas per hour, similar to those used at Brockenhurst station. (See Fig. 9.)

very clearly in emergency lighting; for example, for illuminating docks while a vessel is unloading, roadway alterations, and buildings in course of construction. The London County Council now use acetylene flares and hand lamps to a very large extent for tramway repairs, and they are also being largely employed on railways. The author is informed on very good authority that to provide efficient light for a gang of men acetylene effected a saving of about 60 per cent in cost of light and a further saving of quite 70 per cent in cost of labour over that of the old-fashioned oil flares.

As an illustration of the use of acetylene for remote railway stations, we may take Brockenhurst Station on the London and South-Western Railway. This is lighted throughout by acetylene, 200 burners with a total of 9,000 c.-p. in all being employed. All these lamps are furnished with gas from a single central station, the platform burners consuming 1 cubic foot per hour, and the signal light burners consuming $\frac{1}{4}$ cubic foot per hour only.

This quality of acetylene is of even greater value in the case of buoys and beacons in remote situations. Acetylene has, indeed, rendered signal service to navigation. Buoys can be provided with apparatus which enables the light to last for months at a time, and they require to be visited only at very infrequent intervals. It may be interesting to members of the Society to know that a Nobel Prize was this year awarded to Mr. Gustav Dalen, a Swedish engineer, for his inventions in this department. Acetylene buoys are provided with very ingenious automatic devices for switching the light on and off at certain agreed intervals. This not only leads to a considerable saving in gas, but makes the light easier to see at a distance (since the eye is attracted by a flickering light when it might not observe a steady one). Dalen has also invented a "solar valve," which automatically turns off the light when daylight comes, and

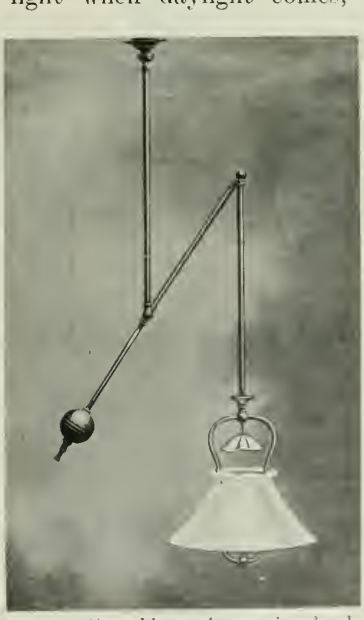


FIG. 11.—Adjustable pendant, using $\frac{3}{4}$ c. ft. of gas per hour. A recent test showed that the illumination 2 ft. below the burner was 6 foot-candles.

turns it on again in the evening when the light begins to fail. This is accomplished by the unequal expansion of two sets of rods—one polished and

one dead-black, a combination which responds to light-energy, but is not affected by heat. It may be added that acetylene flashing lights are now being used for railway signals.

FIG. 12.—Portable lamp with silk shade (lined white inside). The height of burner (consuming ¾ cub. ft. per hour) from table is about 18 inches and as much as 10 ft.-candles is obtained below the lamp.

It has been found that in the case of important stations the system of signals has become so complicated that additional means of distinction are needed. For this purpose flashing acetylene lights are very useful as an additional means of discrimination besides colour.

For spectacular lighting acetylene is at a great advantage, since it can be readily installed at very short notice. An interesting illustration of its employment in this way is afforded by the lighting of the tower of Westminster Cathedral on Coronation night. Three hundred and fifty burners, giving a total of 17,500 c.-p., were employed, and the tower was clearly visible both from Highgate and the Crystal Palace, the complete installations being fixed at three days notice.

Mining Lamps.

Acetylene miners' lamps possess distinct advantages, and have been used to a very great extent on the Continent.

In a report of the International Committee to the British Acetylene and Welding Association, issued this year, it was stated that in France 50,000 acetylene miners' lamps were in use, and in Germany as many as 100,000.

The qualities of acetylene lamps for mines have recently been the subject of careful attention, and suggestions are being drawn up with a view to improvement in durability, strength of burners, and the application of pyrophoric devices, enabling the gas to be very conveniently lighted by the friction of suitable metals. At the request of the German Acetylene Association inquiries have been made by the Prussian Minister of Trade and Commerce into the experiences obtained with open acetylene lamps in the metalliferous and salt mines in Prussia, and a corresponding inquiry has been made by the French Union. A prize of 5,000 francs has now been offered by the United Carbide Manufacturers for the best form of acetylene miners' lamp.

Acetylene has shown itself of considerable value for emergency lighting at sea, and for use at lifeboat stations, &c.

Acetylene can also be used in a specially constructed gun to work as a fog

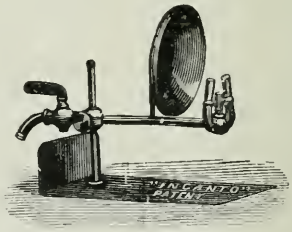


FIG. 13.—Projector lamp fitted with three burners each consuming 1 cub. ft. of gas per hour. At a distance of 18 ft. this gave about 300 c.-p.

signal either on land or at sea, and can be set to work automatically firing every few seconds, or can be fired as required by electricity.

The extent to which acetylene is used by the motorist for lighting has already been mentioned; but in the States, at any rate, it is now being used not only to light the car, but to start the engine, and during his recent tour the author saw motor starters being made by the thousand, and many cars fitted with them and working most satisfactorily. A small charge of compressed or dissolved acetylene is pumped into the cylinder by a simple hand-pump, and fired by the ordinary electric spark. On the table there is a specimen of these starters, together with other pieces of apparatus and accessories used in connexion with acetylene, which the author will gladly explain to any one who is specially interested.

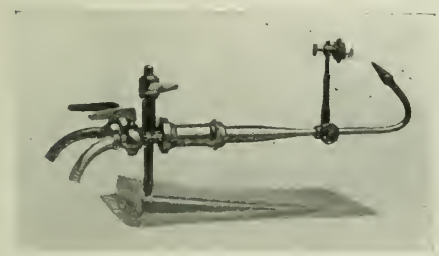


FIG. 14.—New oxy-acetylene projector lamp, using about 7 cub. ft. per hour of a mixture of oxygen and acetylene. At a distance of 18 ft. this gave over 1,000 c.-p. and the light, being concentrated over a small area, is convenient from an optical standpoint.

Acetylene can now be used quite successfully in stoves for cooking and heating purposes; in fact, there is hardly any purpose for which heat is a necessity where acetylene cannot be used. Finally, the author would like to quite briefly mention a few other purposes to which acetylene is at present put.

First and foremost of these is undoubtedly oxy-acetylene welding and cutting, in connexion with which dissolved acetylene is largely used. This hardly comes within the scope of a paper on lighting, but is such an important industrial application of acetylene that it does deserve some mention.

One of the most useful purposes to which acetylene will shortly be put is the cinematograph. A mixture of acetylene and oxygen used on a special disc of ceria, gives a light almost equal to the electric arc; and, in conclusion, this light will be shown in actual operation. Ordinary lime burns away so rapidly that it cannot conveniently be used in the intense heat of the oxy-acetylene flame, but these ceria discs will last quite a sufficient time. Some measurements of the light given by this arrangement were recently made at my office. The candle-power immediately opposite the incandescent disc was found to be nearly 1,100, a value which it would be difficult to attain except by the electric arc. From the optical standpoint the fact of the light being concentrated over a small area—the entire disc is only 22mm. in diameter and the incandescent portion smaller than this—is a great advantage. This lamp consumes about 7 cubic feet per hour of approximately half-and-half mixture of oxygen and acetylene. (See Figs. 13 and 14).

A comparison test of an ordinary acetylene lamp for projection purposes, consisting of three burners, each taking 1 cubic foot per hour, mounted in a row, and backed by a concave reflector, was made. At the same distance away the candle-power was slightly over 300, and, of course, the fact of the flame occupying such a large area means that only a comparatively small part of this light would actually pass through the objective.

In conclusion the author would like to express his indebtedness to the following firms who kindly provided apparatus for exhibition; The Acetylene Illuminating Co. (Sun Valve, Flasher, Signalling Lamp, and Dissolved Acetylene Cylinder); Messrs. Allen & Co. (Acetylene Miner's Lamps.

In order to keep this paper within a moderate space it has been necessary to pass over many applications of acetylene somewhat hastily. But the author hopes he has said enough to show how many are the uses to which this form of illumination is suited.

Petrol Air-Gas Lighting.

By E. Scott Snell.

(Paper presented at a meeting of the Illuminating Engineering Society, held at the House of the Roya Society of Arts, John Street, Adelphi, London, on Tuesday, January 14th, 1913, at 8 P.M.).

[Abstract.—The author first gives a general explanation of the nature of a petrol air-gas plant, and summarizes its advantages. Curves are given for the distribution of light from a Bijou mantle, and the cost is given as 3*d.*–4*d.* per 1,000 c.p.-hrs. Some photographs of a typical installation are presented, and a rough rule derived for the consumption of petrol required to light a certain area. In the latter part of the paper, the principles underlying the design of petrol air-gas plants are explained in detail, and the quality of petrol to be used, the richness of the gas it is desirable to generate, and the nature of compressors, carburettors, and governing devices, &c., discussed.]

Introduction.

The chief object in writing this paper has been to analyze some of the underlying principles of petrol air-gas lighting, and the points which have to be borne in mind in designing good plant. But it has been suggested that a general introduction would be of service to those who are not familiar with this method of illumination, or interested mainly in the conditions of illumination to be obtained from the system.

It may be mentioned, therefore, that petrol air-gas consists simply of air to which has been added a small percentage of petrol vapour. A mixture of this kind can be generated by suitable machines, and subsequently forced through pipes and led into a house to be used in a similar way to coal-gas, the generating plant being conveniently placed in a small outhouse. The motive power may be a hot air engine, the force exerted by a falling weight, or, when available, water power. In any case, a good petrol air-gas machine should work automatically when once it is started, and all that should be necessary is to supply it with petrol from time to time, wind up the weight, &c.

It will be observed that liquid petrol only exists in the plant itself in the outhouse. The pipes led into the house contain only a mixture of air and petrol vapour, and the percentage of the latter is invariably small ($1\frac{1}{2}$ to 6 per cent). The system can therefore be claimed to be very safe when properly designed, for it would hardly be possible for a leakage of petrol air-gas to give rise to serious danger—over 94 per cent of the escape is pure air—and a stream of the gas issuing from a pipe can only be ignited with difficulty. On the other hand, it must be borne in mind that petrol air-gas is not a true gas, but only a mixture of certain volatile hydrocarbons with air, and some of these hydrocarbons may condense if a wrong mixture or an imperfectly designed form of plant be employed. These difficulties, however, should never make themselves felt in the case of a well-designed system.

Gas lighting by means of carburetted air dates back as far as 1831, when it was proposed by Lowe to send air saturated with the vapour of volatile hydro-carbons through pipes to be consumed in burners of the luminous type. An old volume on the subject to be found in the Patent Office Library makes excellent reading for those fond of exhuming the past.

No doubt it was found in practice that a very high degree of saturation was necessary to produce a reasonable light, and the high cost involved, coupled with troubles met with from condensation, probably put an end to such schemes from the commercial point of view. The introduction of the incandescent mantle, however, which allowed the use of mixtures far from saturated, put a different complexion on the matter, and about five years ago a few comparatively successful machines provided a stimulus to inventors, with the result that all sorts and conditions of gas machines began to appear, ranging from the equivalent of a Rolls-Royce to a string of tin cans. Petrol gas, however, had come to stay as long

as there was petrol available, and to-day it is considered to be one of the cheapest, most brilliant, and probably the safest means of lighting where neither gas nor electricity mains can be tapped.

Burners.

Special burners, having nipple apertures much larger than those used for gas, are required for petrol air-gas lighting. (It would, of course, be possible to convert some gas burners into petrol air-gas burners by merely boring out the nipple, assuming that one had suitable tools. Experiments in this direction, however, usually produce excessive noise and roaring when alight.)

The larger nipple used is a distinct advantage, since it renders the burners much less liable to be choked up by dust. The fact that such a large proportion of air is taken into the burner through the pipes also enables us to obtain, at the comparatively low pressure of 1½ in., conditions of combustion comparable with those obtained by high-pressure gas. Some discussion has taken place as to whether higher efficiencies can be obtained by an increase in pressure. The writer does not think that any great advantage could be gained in this way. On the other hand, it would, of course, be possible to use higher pressures by suitable design of plant and burners were there any gain to be derived by doing so.

The natural result of these favourable conditions for combustion is that the size of inverted mantle commonly used for petrol air-gas lighting (the Bijou type) yields a much more brilliant light than would be obtained with corresponding mantles with low-pressure coal gas. Some tests recently carried out at the County Works showed that some new mantles were giving 70 to 80 c.-p., while others in the showroom, that had been in use for some hundreds of hours, were still giving 48–50. These tests were made on the mantles alone, without any form of shade, and the values quoted are practically equivalent to mean lower hemispherical candle-power. Very different results are quoted by different petrol air-gas firms for the light obtainable from bijou mantles, and there is no doubt that this is a matter that would well repay independent investigation.

It must, of course, be admitted that the light from mantles deteriorates in the course of life, and the author has tried to secure from consumers some actual data as to the life of mantles in use. Unfortunately, the results obtained appear to differ so widely, according to the nature of the installation and the practice of the consumer, that one hardly feels justified in quoting any general figure; perhaps some one will come forward in the discussion with data on this point.

Petrol air-gas lighting can, of course, be applied to either inverted or upright burners, but the type that is most widely used is the inverted bijou. Used with the County plant, such burners are guaranteed to consume not more than one-ninetieth of a gallon of petrol per hour; but as a matter of fact the consumption is often considerably less than this. Later on in this paper the question of cost is considered in greater detail, but for the moment it may be said that on the basis of the above figures and the present outrageous price of petrol, the cost of petrol air-gas lighting per thousand candle-power hours should not exceed 3*d.* to 4*d.*

Besides the bijou type special burners consuming half the above amount of petrol can also be used, but there does not seem to be a great demand for these small units.

On the other hand one might suppose that for factory lighting and industrial illumination generally, more powerful units would sometimes be useful. It is a curious fact that it is difficult to get the same high efficiency from larger mantles. This experience will probably be confirmed by those who are concerned with coal gas lighting. At present the usual course is to assemble a number of small units when a very powerful unit is needed.

It may be well at this point to refer to a question that not infrequently figures in petrol air-gas lighting lite-

rature, namely the colour of the light. From some remarks that have been made on this point it might be supposed that this was widely different

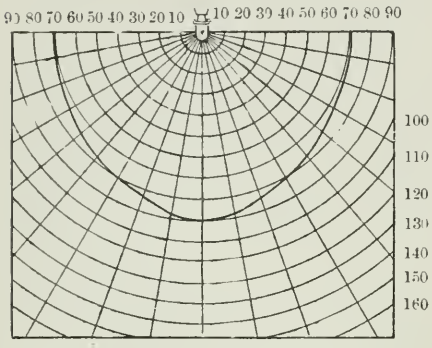


FIG. 1.—Distribution of light from bare mantle (consuming one-ninetieth gallon of petrol per hour). Intensity immediately under mantle 90 C.P. (approx.).

from that derived from coal gas. The light yielded by a petrol gas mantle should be almost exactly similar to that obtainable with *high-pressure gas*

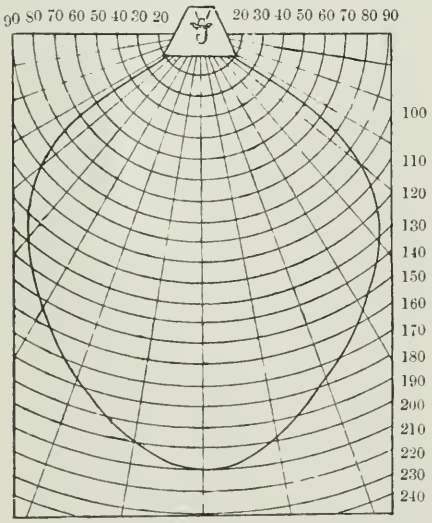


FIG. 2.—Distribution of light from burner (consuming one-ninetieth gallon of petrol per hour), equipped with opal shade. Intensity immediately under mantle, 210 C.P. (approx.).

lighting, since the temperature is substantially the same; it has, however, undoubtedly less green in its composition than has the light from low-pressure coal gas mantles.

Shades and Fixtures.

It is obvious that in many cases the use of a proper reflector is of great value, and has as much to do with the efficiency of the system from an illuminating engineering standpoint as the nature of the burner. In country houses people do not, as a rule, ask for a very brilliant illumination, but in factories, mills, &c., it will often be necessary to concentrate all the light on the spot where the work is actually carried out. With the 70 c.-p. petrol air-gas burner and a suitable shade, a very brilliant illumination can easily be obtained. As an illustration of the effect of a shade for this work there is shown side by side the polar curves of light distribution taken at the County Works recently for a bare bijou mantle, equipped with a conical opal shade. It will be seen that the candle-power immediately below the mantle, where the light is usually mainly required, is increased from about 90 to over 200 c.-p.

Opportunities for Petrol Air-Gas Lighting.

Petrol air-gas lighting can claim to have a special field in places where neither gas nor electricity is available. The simplicity of the system is a great recommendation, and when a good system is used the attention required from the consumer is very small indeed. On the other hand, the very advantages of the system have often been something of a drawback to the industry; for the illumination obtainable by petrol air-gas lighting is in general so much better than that derived from ordinary oil lamps, and the convenience of being able to turn it on and off in the same way as gas appeals so strongly to the average owner of a country house, that he is apt to lose sight of the distinction between a good petrol air system and a very inferior one. He is inclined to take the first plant that meets his notice, dash off a testimonial, and then, as defects subsequently reveal themselves, repent at leisure. This could hardly be otherwise, seeing that the outsider has so little opportunity of getting trustworthy independent information as to which are the best petrol air-gas machines. At the present time there are probably be-

tween 30 and 50 different makes of plant on the market. Some of them are thoroughly trustworthy, and can be relied upon to work year after year, and give the consumer practically no trouble; but others are quite the reverse. Some of the weaknesses that have revealed themselves in some forms of plant and have discredited petrol air-gas lighting in the past, are really quite avoidable by proper design. It is very often found by consumers that the light is affected by the number of burners turned on, and that the illumination is very much diminished when the plant is run at its full capacity. This is sometimes due to the fact of piping of too small a size being installed, but it is more frequently due to defects in the design of the plant, leading to variation in the composition of the mixture as more or less lights are turned on. It need not be said that this should not occur. A recent test on this point was made at the County Light Works, the light from an incandescent mantle being observed with a photometer continuously, while the load on the machine was suddenly varied over a very large range. The test took place over a period during which the machine made a large number of strokes, and therefore the contents of the gas holder was completely changed several times, but no sensible variation in the light was noticed.

Another defect that has revealed itself is the effect of temperature on the performance of a plant. Petrol air-gas is not a permanent gas, and it is possible that at low temperatures some of the volatile hydro-carbons may condense, especially if the degree of saturation is high. On this point something will be said later. Condensation of this kind is a serious fault. If it occurs in the pipe leading from the outhouse in the open air the action of the plant would, of course, be impeded, but no danger might occur. But the existence of liquid petrol in the pipes inside a house is a thing which is still more undesirable.

These points are mentioned merely to show what can take place with a defective installation. On the other hand, experience has shown that with a sound installation there can be no danger of this kind even in the coldest weather.

A Typical Installation.

Some details of an actual typical petrol air-gas installation will give an idea how the cost will be expected to work out in practice. These refer to a country house in Essex utilising a fifty-light County plant. Figs. 3, 4, and 5 are photographs of several rooms taken entirely by artificial light. The billiard table shown in Fig. 4 is lighted by eight Bijou burners in cardboard shades, and a measurement of the illumination on the table showed that a value of 16 to 18 foot-candles was obtained.

Curiously enough, the author is informed that almost exactly the same value was found at Whitehall Club for an electrically lighted billiard table, so that this value of illumination would seem to be about the standard for billiard tables.

The billiard table is in a large handsome room, an idea of which should also be gathered from Fig. 4. This is approximately 40×20 ft., and is lighted up by a series of eight bracket lights, also carrying Bijou burners, distributed round the room. The general illumination in this room is, from actual tests made, about 1 foot-candle.

The next illustration shows a bedroom lighted by a single Bijou burner, placed over the dressing table. The illumination on the table is about 8 foot-candles. This burner is controlled by a press button pneumatic switch placed beside the bed.

Consumption figures kept by the owner show that his petrol tank is replenished with 6 galls. of spirit every ten days at the present time of the year, an average consumption of ·6 of a gallon per night. From information given of the number of lights used during an average evening, this works out at a good deal over the ninety light-hours per gallon guaranteed by the County Light, Ltd.

In conclusion, perhaps one might give a rough rule for lighting interiors, as the result of a recent test at the

County Light works. This assumes (as is frequently the case for industrial installations, though not always in country houses) that one wishes to produce a uniform illumination all over the room. It was found that in a room 10 ft. square with fairly light wallpaper, an illumination of 4 foot-candles could be obtained at the working plane by two burners each consuming about one one-hundredth of a gallon of petrol per hour. From this we see that, generally speaking, one-hundredth of a per hour gallon should yield $\frac{4 \times 100}{2} = 200$ lumens; from these data one might, perhaps, suggest a rule that one gallon of petrol per hour should give, roughly, one hundred times this amount—*i.e.*, 20,000 lumens.*

It is hoped that the foregoing data will give some general idea of the possibilities of petrol air-gas lighting. The remainder of the paper discusses in greater detail some of the points connected with the design of petrol air-gas plant.

Composition of Petrol Air-Gas.

Petrol gas consists entirely and solely of air, into which is evaporated and held in diffusion the vapour of one or more volatile hydrocarbons. The word "petrol," although a proprietary name, has come to embrace any liquid, or mixture of liquids, belonging to that portion of the paraffin series (C_nH_{2n+2}) in which the specific gravity lies between 0·626 and 0·760, a valuable physical property of which is their volatility, as their vapours will remain absorbed in air to an amount at least equal to that necessary to produce complete combustion, and that at reasonable temperatures, or temperatures the highest of which would not be referred to as more than "warm" to the human touch. There are usually also present portions of the C_nH_{2n} group, especially in spirits from Eastern sources. Petrol gas is not in any sense a chemical production; there is no affinity between air and hydrocarbons, and the change back from petrol gas to its constituents is readily effected by sufficiently lowering the temperature or increasing the pressure, when the vapour will condense out as a liquid.

The essential condition of the efficient use of any gas with a mantle is that the flame temperature should be as high as possible. Now, the highest temperature is necessarily obtained by burning the fuel in close physical mixture with the air with which it is about to unite in the phenomenon of combustion, and in such proportions that neither the fuel nor the air is in chemical excess. If there is excess fuel combustion will be incomplete; if excess air, there is a larger volume of gas than necessary sharing the heat units liberated, and in each case the temperature falls short of the maximum. To find out the ideal proportions of air to petrol. the fuels must be examined in the light of the equation representing combustion. Taking Hexane (C_6H_{14}, sp. gr. 0·663), which is the chief constituent of the light petrol used in weight-driven machines and in most hot-air engine-driven plants, combustion may be represented as taking place according to the formula: $2\ C_6H_{14} + 19O_2 = 12\ CO_2 + 14\ H_2O$, *i.e.*, 2 vols. of vapour require the 19 vols. of oxygen contained in [$19 \times 4{\cdot}81 =$] 91·3 vols. of air, or 100 vols. of mixture contain 2·14 per cent vapour.

With further calculation one can compile a list of the proportions for other members of the series, arranged according to the specific gravity:—

		Sp. gr.	Ideal mixture.
C_5H_{12}	Pentane	0·626	2·53%
C_6H_{14}	Hexane	0·663	2·14%
C_7H_{16}	Heptane	0·688	1·86%
C_8H_{18}	Octane	0·719	1·64%
C_9H_{20}	Nonane	0·742	1·46%

It will be observed that the heavier the spirit used, the larger the proportion of air necessary to burn it.

At the same time it must be pointed out that these proportions are the same as those required to give the greatest explosive effort if fired in a

* A lumen is the unit of quantity of light, and is equivalent to an illumination of one foot-candle distributed over one square foot. In calculating the total flux of light over a floor, table &c., one merely multiplies its area by the intensity of illumination. Thus in the above case 4 ft-candles over 100 sq. ft., or 400 lumens, were produced.

FIG. 3.—Showing illumination of large room in a country house (40 x 20 ft. approx.), lighted by eight Bijou burners on brackets with head shades. General illumination 1 ft.-candle.

FIG. 4.—Illumination of billiard table in same room by eight Bijou burners in cardboard shades. Illumination on table 16-18 ft.-candles.

confined space. Explosion itself is only the effect of very rapid expansion consequent upon the sudden liberation of heat in an expansible medium, the conditions being the same as those necessary to produce the highest temperature for any other purpose.

The author is of the opinion, based upon practical experience, that it is very objectionable to have a pipe system ending in a storage holder containing an explosive gas.

Fortunately, it is not necessary to use such a mixture, for one can make use of that most extraordinary property of petrol vapour, viz., the excessively small range over which its mixtures with air are inflammable. Although, for instance, with Hexane the mixture giving with air the maximum explosive violence contains 2·14 per cent of vapour, yet if the amount of vapour is increased to as much as 5 per cent, it not only ceases to be explosive, but becomes uninflammable until the addition of further air has reduced the percentage of vapour present.

The author, therefore, has always advocated the use of a gas containing at least 5 per cent of vapour in its composition, for in the event of a flame by any means lighting back into the pipes it is immediately self-extinguished, instead of resulting, as has happened on several occasions within his knowledge, in a damaging explosion.

It must not be thought that the use of a "rich" mixture results in a heavier consumption than when a "poor" one is used. The gas required at the point of combustion—the mantle—must be that giving the highest temperature, and when a rich mixture is employed, dilution is effected locally by the use of injector burners with adjustable air-sleeves, instead of, as with a weak gas burning, the mixture at the end of a gauze-covered tube without the addition of further air In each case the proportions consumed at the mantle are the same, as is the consumption of petrol for a given candle-power

The composition of petrol gas is usually spoken of as a percentage, but an alternative designation is that of "so many cubic feet per gallon of petrol"; and one often wishes to transpose one into the other. To do this one requires to know the relative expansion undergone by the petrol in changing from the liquid to the vaporous state. In a pure substance, given the chemical formula and the specific gravity, and knowing that at 0° C. and 760 mm. the molecular weight in pounds occupies 359 cubic feet, we have for Hexane that one gallon, when vaporized, will occupy

$$\left[\frac{359}{86} \times 6{\cdot}63 =\right] 27{\cdot}7 \text{ cubic feet.}$$

Again, an interesting comparison is possible showing the effect of specific gravity on the vapour obtained per gallon. Calculations for other light hydrocarbons give :—

	sp. gr.		cubic ft. per gallon
Pentane	0·626	gives	31·2
Hexane	0·663	,,	27·7
Heptane	0·688	,,	24·7
Octane	0·719	,,	22·6
Nonane	0·742	,,	20·8

If the specific gravities are plotted against the cubic feet per gallon, a curve is obtained from which the relative expansion of any particular petrol can be read off. As examples of the transposition of one designation into the other, we have, in a 1·5 per cent mixture from 0·719 sp. gr. spirit one gallon makes 22·6 cubic feet vapour contained in $\left[\frac{100}{1{\cdot}5} \times 22{\cdot}6 =\right]$ 1,500 cubic feet of mixture Similarly, a 6 per cent mixture from 0·688 sp. gr. spirit would give $\left[\frac{100}{6} \times 24{\cdot}7 =\right]$ 410 cubic feet per gallon.

Referring again to the proportions of petrol air-gas, although it is advisable to make a gas of at least 5 per cent to secure immunity from internal inflammability, yet the upper limit of richness has to be considered. The governing feature here is the nearness of the condition of the gas to "saturation" in any piping it may have to pass through. The objections to condensations in the pipes are obvious—*e.g.*, loss of calorific value, blocking of passages, and, in extreme cases, the

dripping of liquid petrol from brackets and pendants in rooms. In order to know how rich we may make the gas with safety, it is necessary to know something about the volatility of the fuel itself. Our information with respect to the pure substances, such as pentane, hexane, &c., is complete and accurate, curves of the vapour tensions of which have been plotted by well-known physicists, and may be found in the *Transactions* of the Chemical and like Societies. Similar information for the mixtures of hydrocarbons which we use is, unfortunately, very scanty; nor, moreover, are we certain of always getting the same proportions of ingredients in every tin with a certain label. Again, even if we know the ingredients of any petrol, both qualitatively and quantitatively, it is a very difficult matter, if not an impossibility, to predict the vapour pressure of the combination, as it is doubtful whether vapours obey Dalton's laws closely enough to allow us to prophesy. The author does not, therefore, propose to go further into the theoretical aspect, and would refer any one interested back to a paper read by him in 1911 before the Society of Engineers, where the theory of the subject is investigated more closely.

It is out of the question for practical —that is to say, commercial—purposes to make a rich mixture with other than the petrol known as "Swan" or "Anglo-Special," sp. gr. 0·680–0·695. With these petrols the writer has never in practice found any condensation, even when pipes have run long distances out of doors in exposed positions. On the other hand, experimental work with a self-burning mixture made from 0·670 spirit has shown condensation when passed through a coil surrounded by water drawn from a tap in the room.

FIG. 5.—Bedroom lighted by a single Bijou burner over dresssing table, controlled by push-button pneumatic switch. Illumination on dressing table 8 ft.-candles.

The conclusions arrived at, therefore, are that, where a rich gas is made, no spirit heavier than sp. gr. 0·695 should be used, and if it is desired to employ commercial petrol (or that used in motors) it should not be heavier than 0·710 or 0·720, and it

is essential then to use a self-burning gas. Such heavy petrol as that used in motor-'buses and lorries (0·760) should be avoided, for either a large amount will be rejected by the carburettor or else, if the spirit is completely evaporated, condensation may be expected to a serious extent, except in artificially warmed positions.

Calorific Value.

The calorific value of members of the paraffin series included in the petrols may be taken as about 20,000 B.T.U.'s per lb. As a matter of fact, there is a slight increase in B.T.U.'s per lb. as the specific gravity gets lighter; but it is not of any appreciable value, and the round figure is near enough for all practical purposes. It will be seen, however, that, as we are forced to buy our spirit by volumetric measurement instead of by weight, the heavier the petrol the greater the number of heat units per tin. For example, a gallon of light spirit would contain [$6{\cdot}8 \times 20{,}000 =$] 136,000 B.T.U.'s, as against [$7.6 \times 20{,}000 =$] 152,000 B.T.U.'s per gallon of "Crown" spirit. Were it not for the above-mentioned disadvantages attendant upon the use of the heavier fuel, this would be a point well worth consideration.

Knowing, then, the "make" of gas in cubic feet per gallon, the calorific value of the gas is only a matter of simple calculation. For example, a 1·5 per cent gas from 0·720 spirit (1,500 ft. per gallon) would have a calorific value of $\left[\frac{7{\cdot}2 \times 20{,}000}{1{,}500} =\right]$ 94·6 B.T.U.'s per cubic foot, and a 6 per cent gas from 0·680 petrol would have a calorific value of $\left[\frac{6{\cdot}8 \times 20{,}000}{410} =\right]$ 331 B.T.U.'s per cubic foot, the latter figure comparing not too unfavourably with some specimens of coal gas. The author has corroborated these figures by experiment.

The advantage of the rich gas is obvious when the carrying capacity of pipes is considered. The specific gravity of the two types not differing substantially—the specific gravity of petrol gas may be taken as unity for practical purposes—it will be seen that a given pipe is capable of carrying $3\frac{1}{2}$ times the value with rich gas as with the weak type, with the same fall of pressure in each case. Now it requires practically the same initial pressure of supply in each case, the resistances of gauzes and nipples with the weak gas balancing the loss of efficiency by using the injector principle in the rich gas; hence the advantage is also apparent in the relative powers required to drive an installation of the same size in each case. In installations of the plant designed by the author, the County system, $\frac{1}{4}$-in. barrel, and even $\frac{1}{8}$-in. barrel, is successfully used, whereas it will be found that weak gas plants seldom allow of any piping less than $\frac{3}{8}$-in.

Candle Power and Cost.

The question of the cost of light from petrol at the present time is one of great interest and a great deal of argument: firstly, because no two makers seem to agree upon a definite figure, such wide claims being made as from $\frac{1}{2}d.$ to $4d.$ per 1,000 candle-power-hours; and, secondly, because the price of petrol itself has fluctuated between excessive extremes. One point the author would insist upon, and that is, that the price of light from petrol must be a function solely of the price and value of the spirit itself, and cannot be influenced by the methods of its generation, given that the apparatus does its work efficiently, leaving no residue in the carburettor. Here, again, where one feels the need of some independent authority to fall back upon, the unbiassed information available is very scanty and incomplete.

Prof. Vivian Lewes reports an efficiency of 5,000 candle-power-hours per gallon, whereas Mr. O'Connor gives a test which reduces to about 6,500 c.-p.-hours per gallon. The author was present at a test giving 4,500 c.-p.-hours per gallon; whilst Mr. Strode issued a report which worked out at 6,000 with one burner, and 9,350 c.-p.-hours per gallon with another, both with rich gas. In some rough tests recently made at the works of the County Light, Ltd., the candle-power

of a burner with a new mantle, guaranteed to consume not more than one-ninetieth of a gallon an hour, gave a maximum reading of 70 c.-p., which reduces to 6,300 c.-p.-hours per gallon. The average of all the foregoing figures is 6,800 c.-p.-hours per gallon. With petrol at the famine price of 1*s.* 9*d.* net, this is only 3.1*d.* per 1,000 c.-p.-hours. It should be pointed out, too, that all the above tests relate to plants consuming light spirit. There would be a substantial pecuniary gain from the use of heavy petrol if the whole of the spirit were used for giving light, as in the case of a weight-driven plant using 0·680 fuel. The light obtained from different fuels is proportional to their calorific values, and we have for light spirit $6{\cdot}8 \times 20{,}000$ B.T.U.'s for 1*s.* 9*d.*, and for heavy spirit $7{\cdot}6 \times 20{,}000$ B.T.U.'s for 1*s.* 2*d.* The relative values are, therefore, $\frac{6{\cdot}8 \times 20{,}000}{21} : \frac{7{\cdot}6 \times 20{,}000}{14}$, or 1 : 1·67; *i.e.*, the heavy petrol would be over half as valuable again as the light one, and one would consequently expect the price of 1,000 c.-p.-hours to reduce to 1·85*d.*, as against 3·1*d.* This calculation, however, neglects to take any account of the waste heat (waste as far as producing light is concerned) necessarily used for carburation purposes and driving an engine, nor does it notice the value lost in waste from carburettor and condensation in mains.

When these factors are taken into account, there is probably no vast gain from the use of the heavier spirit. At any rate, the author and his partners have not up to the present considered the proposition sufficiently alluring to justify their putting on the market a machine to use heavy petrol, entailing as it does the use of an explosive mixture and heat for carburation purposes. In view of recent correspondence in a technical journal, the author hopes this point will receive some attention in the discussion.

Design of Plants.

Having discussed at some length petrol gas in the abstract, the means of generating it requires some consideration. All petrol gas machines resolve themselves eventually into a means for supplying air under pressure, a motive power, a carburettor and means for supplying it with petrol, and a small storage holder (usually employed for governing purposes). Sundry embellishments, such as driers and thermostats, are peculiar to certain systems, and their use is not in general essential.

Motive Power.

Dealing with the motive power first, the theoretical power required may be readily calculated. With a 40 c.-p. unit an inefficient burner may consume as much as 12 cubic feet per hour, and with a 6% gas as much as 4 cubic feet per hour (excessive consumptions are taken for calculation purposes). In each case an initial pressure of at least $1\frac{1}{2}$ in. of water column would be necessary, so that for every hour each unit is in use there would be absorbed $[1\frac{1}{2} \times 5{\cdot}2 \times 4 =]$ 31·2 foot-lbs., and $[1\frac{1}{2} \times 5{\cdot}2 \times 12 =]$ 93·6 foot-lbs. of work respectively. To take a concrete case, let us examine a house with fifty points in all. Experience shows that a winter night's consumption is somewhere in the neighbourhood of $[20 \times 6 =]$ 120 light-hours. If a 20-ft. drop were provided to run a weight-driven plant with one winding per day, the theoretical weights would be

$$\left[\frac{120 \times 31{\cdot}2}{20} =\right] 187{\cdot}2 \text{ lbs., and}$$

$$\left[\frac{120 \times 93{\cdot}6}{20} =\right] 559{\cdot}2 \text{ lbs.}$$

respectively.

Needless to say, such figures are never reached in practice, as there is a heavy loss of efficiency: firstly, in providing the supply of air under pressure; and, secondly, in forcing that air through the carburettor into the holder. Thirdly, it has been the author's experience that, to ensure against occasional stoppages, a machine should be so designed that it can run on a load of at least 25 per cent more than will just make it work, and that without undue strain on any part of the apparatus.

The low powers involved accounts for the popularity of the two most

prominent forms of motive power, viz., falling weights and hot-air engines. Of the two methods a comparison on the score of ease of handling and general utility necessarily favours the weight drive. The fall of weights—since there is no question of starting and stopping and a minimum rate of working—is always arranged to be exactly proportional to the demand in the service; hence a light or lights, even up to full load, is always ready at any time during the day or night, provided the weights are still off the ground, and the question of "stand-by" charges disappears. With the engine, however, the cost of running with no load is not inconsiderable, since to be comparable with the weight-driven system it must run continuously throughout whole nights. People usually prefer to shut it down for the night, when the duty of shutting the engine off falls to the last man in. Storage holders mitigate this objection to a small extent, but it can only be a small extent, since one burner may consume as much as 12 cubic feet per hour. The hot-air engine scores, however, in the matter of prime cost, as no gantry is necessary, and it can, so to speak, be dumped down anywhere.

Compressors.

With weight-driven plants this usually consists of a wet gas meter driven the reverse way, so as to force air instead of being forced by it. An objection in the author's eyes is, that it is a difficult piece of apparatus to take to pieces, and unless very well and carefully made, the internal webbing forming the compartments sometimes comes unsoldered and springs, causing internal friction and possibly stopping the plant.

In the machine designed by the author he discarded this system in favour of a reciprocating bell running in a water seal. A special gear enables the weights to haul it up whilst it takes in a measured quantity of air, releasing it when full, when it falls by gravity forcing the charge of air, and a measured complement of petrol from a small pump making stroke for stroke with it, into the carburettor. Such a compressor has no internal moving parts, and is removed for examination at a moment's notice, exposing the interior of the outer shell at the same time.

The intergearing wheel type of blower is found very successful with engine-driven types.

Carburettors.

A discussion of the principles of carburetting as applied to gas-making machines is unfortunately outside the time limits of a short paper, but a few points stand out pre-eminently and demand notice. The advantages of cold carburation over the use of heat are twofold. Firstly, if no extraneous heat is added, the carburettor will probably be the coldest spot in the whole system, including the piping, and a guarantee is thus obtained against subsequent condensation; secondly, if there is no necessity for heat in carburetting, in weight-driven types, there need be no flame anywhere on or near the machine. This point is a valuable one in plants where a storage of petrol is placed on the machine.

The author is of the opinion that where possible, carburettors should be fed from tanks placed quite outside the machine shed in order to avoid all risk of fire from carelessness. In the machine designed by him the total petrol in the machine, and therefore in the machine shed, is never more than a few teaspoonfuls at one time, nor is there any chance of an accidental rush of petrol into the shed as the fluid is lifted by the pump out of its tank, and is not controlled by any float-feed or similar gravity device, which, should it fail, results in the flooding of the machine from the storage outside.

Another important point is that air and petrol should always be fed to the carburettor in measured complementary charges, and no machine without a measuring device can be guaranteed to keep a constant mixture under all conditions of running. When air is given a free choice, as in a surface carburettor, where the spirit is always in excess, selective evaporation is practically unavoidable, and compensa-

tion for varying speeds and temperatures with fluctuating load is a very difficult task indeed.

Governing Devices.

Where a holder is used—and any plant without a holder will be liable to grave fluctuations of pressure—its position in its guides is a direct index as to whether the compressor is gaining on the demand and to what extent. It is, therefore, usually coupled up to some mechanical method of retarding the driving mechanism when it reaches a certain height. Where such retarding mechanism takes the form of a band brake the pressure on this band brake puts an added pressure on the holder, and in badly designed plants the lights may become brighter when the brake comes into operation. The author therefore favours a ratchet type of retarder, which has the merit of being either in or out, and never in the position of putting a pressure on the bell to supply a friction effect.

In some hot-air engine plants the bell is so arranged that it lifts a blow-off valve, and allows the surplus air to escape when the supply exceeds the demand. When, however, this valve is linked to a means for controlling the supply of petrol, a little consideration will reveal the fact that such a means of keeping the mixture constant presupposes that the engine always runs at the same speed. Such a method of governing is far from ideal, as one would expect the state of lubrication of the engine to have a large effect upon its speed.

In conclusion, the author would point out that the foregoing paper is not to be considered in any way as a thorough exposition of the theory of petrol gas. His aim has been, rather to touch more particularly upon points which are of a controversial nature, in the hope that by so doing he may be able to raise a discussion of particular interest to manufacturers and to those interested in the subject.

Discussion.

The Chairman, after a few introductory remarks called upon Mr. Butterfield to open the discussion on acetylene lighting.

Mr. W. J. A. Butterfield said a point which struck him while the paper was being read was that the systems of lighting by combustion in which the greatest economy per heat unit was secured were those in which a mantle was used, and preferably an inverted mantle. Acetylene was at a disadvantage in that respect, for although upright mantle burners had been used a little, the general practice was not to use them, and inverted mantle burners, though invented, were practically not used at all. The reason was that the natural luminous flame of acetylene was so extremely good and so very pleasant that it surpassed any other self-luminous flame; but, judging merely by the intensity of the light produced, there was some little sacrifice of economy through mantle lighting being given up for acetylene.

Acetylene had several uses to which no other system of lighting was so well adapted. These were cases where a large amount of light was wanted in conjunction with portability. For instance, for flare lamps it surpassed anything else. Miners' acetylene lamps also were extremely good for use in metalliferous mines, but from what he had seen miners had a prejudice in favour of candles. He believed that they retained any candles which they saved in the course of a week as a perquisite, whereas they did not get any credit for carbide saved. Other obvious instances of the advantage of acetylene as a portable light were in connexion with motor-car lighting and buoys. He was much interested to hear about the use of the oxy-acetylene flame for producing a light with ceria. It reminded him of the old attempt to produce a superior "lime-light"

by the use of zirconia with oxy-coal-gas, and he would rather like to know whether ceria had been tried with oxy-coal-gas. He was quite prepared to believe that the effect would not be nearly so good as with oxy-acetylene.

Mr. F. S. Thorn, who had been associated with Mr. Hoddle for many years, said some information had come through since Mr. Hoddle wrote his paper from the manager of a department in a public body relating to a comparison between acetylene flare lights and the old-fashioned oil flare lights. Two acetylene flare lights had been compared, principally as regards costs, with two oil flare lights. During one week's test the saving effect of acetylene over the oil flares was, in consumption, £2 13*s.* 1*d.*, the candle-power being approximately the same. As regards attendance, cleaning, trimming, &c., the cost in the case of acetylene was £1 6*s.* 5*d.*, against £3 19*s.* 6*d.* for oil. As an acetylene engineer he had been intensely interested in Mr. Scott-Snell's paper, and what struck him most in looking at it was that there seemed to be a considerable number of pitfalls and stumbling-blocks in the use of petrol air-gas.

The Chairman then invited Mr. Butterfield to make some remarks on Mr. Scott-Snell's paper.

Mr. Butterfield said Mr. Scott-Snell had covered the ground extremely well, and, generally speaking, he agreed with him that the richer gas, the 5 per cent mixture or thereabouts, was preferable to the poorer gas; but, nevertheless, he thought in some respects the poorer mixture had the advantage. It was a little easier to get the exact proportions requisite for perfect combustion in the burner when the air-gas was prepared in bulk, as it were, in the equalizing or governing gas-holder than if one depended on producing the proper mixture at the burner by injecting action, because slight variations in pressure, or a little dust or blockage of the nipple, &c., affected the proportions in the latter case. There was no doubt about the economy of air-gas lighting, even at the present high price of petrol.

Referring once more to Mr. Hoddle's paper, he said there was a point with regard to the making of heating stoves for acetylene involving the use of the Bunsen burner. Mr. Hoddle had condemned the use of the Bunsen burner for lighting by acetylene. He would like to know whether any maker of acetylene stoves had tried to design one of the reflector type, with a copper reflector and using luminous flames. It seemed to him that for heating purposes it would be much easier to make a fire of that type than to make one with the Bunsen burner, for he knew from experience in laboratories where coal-gas had not been obtainable that acetylene was a rather troublesome thing to use in Bunsen burners, even of special design.

Mr. R. J. Pinnock expressed the opinion that the prospects of petrol air-gas were very favourable, and there were certain purposes for which it was particularly suitable. On the other hand, there were a great many important points, such as the efficiency of the lights, and their effects on eyesight, in addition to the technical points involved in the design of plant, on which great differences of opinion were expressed. Personally he had the impression that the effect of the light was most soft and pleasing.

A considerable number of machines had recently been invented, and the fact that many acetylene firms were now interested in petrol air-gas would seem to augur well for the future of this system of lighting. Much of the discussion that evening had turned on the quality of mixture desirable. He believed there were present gentlemen who held very different views on this matter. It seemed to him, however, that if, as Mr. Scott-Snell said, the ideal mixture of combustion was slightly over 2 per cent, it must be scientifically correct to arrange the machines always to give that mixture automatically to the burner. An advantage of a properly designed petrol air-gas plant was that it could produce such a mixture automatically, and it should not be

necessary for the consumer to adjust his lights, as was often necessary in the case of the richer mixture of petrol gas.

In the gas industry, he understood, the manipulation of the burners demanded the services of a fairly skilful fitter. From the point of view of efficiency pure and simple, there seemed to be much to be said for the poorer mixture.

Mr. W. J. A. Liberty referred to some flare-lights being used for constructional work in Trafalgar Square and elsewhere. He would like further data as to the cost of portable lamps of this description.

Mr. Donnithorne remarked that Mr. Scott-Snell had put the case for a strong mixture very ably indeed, but the advocates of the weak mixture were quite prepared to grant Mr. Scott-Snell all his points, and yet they would have a very favourable case. Mr. Scott-Snell himself admitted that there was an advantage of 60 per cent or over in the matter of price between the weak mixture using a heavy spirit and a rich mixture using a light spirit. That was a very powerful argument on the side of the weak mixture. Then there was the point that Mr. Butterfield mentioned, namely, that the weak mixture was more complete and homogeneous than the strong mixture, and he thought it was generally recognized that, in the matter of the combustion of the gases, the intimacy of the mixture was one of the most important points in obtaining complete combustion and a hot flame. He had never had the opportunity of taking any tests of rich mixtures, but he imagined that if a cold surface were brought very near to the top of the Bunsen burner on a rich mixture a deposit of soot would be obtained; but with the weak mixture this had been found to be absolutely impossible, showing that the minute the gas caught fire complete combustion took place. That was one of the most important points, he believed, in getting a good efficiency.

He did not know much about condensation. Figures were very hard to get. As Mr. Scott-Snell said, there was always a proportion of C_nH_{2n} present, and that was a spirit which, for a given gravity, had a very much lower vapour pressure, and if it was present it would condense. At the present time two spirits of the same gravity which behaved quite differently were sold by different makers; but if the proper spirit, of a gravity between 720 and 760, was obtained, under ordinary circumstances there should result a good burning mixture which will not condense. Some fraction of 1 per cent may come down, but when there was the 60–70 per cent margin of price to play with they could afford to have a fraction of 1 per cent, and yet possibly show a saving.

Mr. R. W. A. Brewer said that it was with great pleasure that he spoke on Mr. Scott-Snell's paper, because the author had dealt with the subject so ably and scientifically. In all matters of this sort it was only in dealing scientifically with the problem of carburation of liquid fuel that definite data were obtainable, and definite conclusions arrived at.

Dealing with one or two aspects of the rich as compared with the poor mixture, he said he was glad that the author had pointed out that what is meant by a rich mixture is not what the public generally imagine a rich mixture to be. The general public compared a rich mixture with coal gas, as forming an explosive mixture readily with air. But Mr. Scott-Snell had pointed out that it was only relatively a rich mixture, in comparison with those mixtures which are of the 2 per cent order. In speaking of this rich mixture we must not run away with the idea that the leakage from a pipe was going to be at all a dangerous thing. That point was often raised against the rich mixture system, and it was absolutely fallacious. He was glad that this fallacy had been expounded.

Furthermore, there was an important thing which one must bear in mind in considering a piped gas system, and that was the cost and appearance of the piping and fittings. Mr. Scott-Snell had clearly shown it to be a fact that in his system the piping was very much

smaller than in other systems using the same fuel; this was an important point. Again, there was the question of the power required to propel the gas through the piping. He would like to call the attention of Mr. Scott-Snell to the calculation he gave on p. 86. This appeared to be rather elusive and incomplete, for the author had not clearly defined his units and constants. Also in speaking of British thermal units, would the author kindly make the "T" into "Th." He had been called to task himself for putting "B.T.U." when "B.Th.U." was meant. It was an important thing in a matter of this sort to get one's units right.

He would also like to call attention to a very important factor in connexion with the carburation of air by petrol, namely, the distinction between plants that used heat and those that did not. Mr. Scott-Snell made an important point that the plant in which he is interested does not require external heat in order to effect the carburation. Anybody who had studied the question of carburation must be alive to the very great difficulties that occurred in dealing with fuels of various boiling points, such as are met in ordinary commercial practice, especially when one was considering the adoption of one plant or another, or taking into account the various fuels. The matter was an important one. Assuming that the area of the surface of the plant was of sufficient size, and that the fuel was in contact with the air for a sufficient period, there was no reason why the abstraction of the heat from the atmosphere should not be sufficient to overcome the latent heat of evaporation. In Mr. Scott-Snell's system that was the case, and he was also right in stating that the temperature of the carburetting apparatus should be the lowest temperature of the whole system, so that if there was a tendency to condensation, or any other failure of vapour to remain in suspension in the system, that would occur in the carburettor, where its effect would be immaterial.

There was one other thing in an intermittent system that required considerable thought, namely, the "time element." For example, if for any apparatus the time during which a certain volume of air was in contact with a certain volume of fuel was always constant, and the fuel was of constant composition and presented the same surface to the air, then one might expect a uniform gas. If, however, the contact periods or the periods of carburation vary, we should undoubtedly get some selective evaporation, and the result would be that the mixture would not be homogeneous under all conditions.

In conclusion, Mr. Brewer asked the author if he or any of his friends had tried the carburation of air by means of any volatile fuel other than the petroleum series. Whether, for instance, he had tried benzol, or any commercial product of that nature. There was no reason why such a fuel should not be used, as it appeared to be cheap and commercial; and certainly its price would not be controlled, as is the price of the fuel at present, by a very powerful group.

Mr. Blatchley said that when he first got to know something of petrol gas, in partnership with Mr. Scott-Snell, it was almost the universal practice to use a weak "2 per cent" or "1½ per cent mixture." Mr. Scott-Snell soon came to the conclusion that this was bad practice, and for the last three or four years had been conducting a sort of campaign in favour of the richer, or "6 per cent" mixture.

Well, he thought Mr. Scott-Snell had established his contentions beyond dispute. Though, he believed, practically all the petrol gas manufacturers in London had been invited to this paper, and the same thing was true of the paper Mr. Scott-Snell read some time ago at the Society of Engineers, the Chairman had had to make quite a pathetic appeal for an advocate of the weaker mixture. Mr. Donnithorne had been the only one to respond, and his defence of the weak mixture was confined to one thing, viz., that *if* heavy petrol were used—and the speaker admitted that this could only

be done with a weak mixture—there was a saving in cost. He (the speaker) quite agreed that there would be such a saving, and a good saving, *if* the other objections to the use of heavy petrol were ignored or risked. That is to say, condensation in the pipes, waste in carburettor, &c.; but the really serious objection to the use of heavy petrol in the speaker's opinion was the very fact that only a weak mixture *could* be made from it with all its attendant defects—its explosive nature, low calorific value (involving the use of large pipes or high pressures), unsuitability for heating and cooking apparatus, and the other well-known objections.

For certain uses there might be much to be said for heavy petrol and a weak mixture, especially in hot climates. But he was quite sure that for country house lighting, where a high standard of work was required, the richer gas was the right one to use, as also for any place where heating or cooking was required. For Colonial use he thought a weak mixture was more suitable, especially as there might be some difficulty in getting the best petrol.

Dr. R. Lessing (*communicated*): With regard to the question of high- and low-vapour contents of the petrol air-gas, it appears to me that the "poor" gas is preferable to the "rich" gas. As the author agreed, the "rich" mixture depends upon the employment of hydrocarbons of low specific gravity. Since the price of petrol, and more especially the varieties of low specific gravity, shows a rapidly increasing upward tendency, designers of air-gas plant will have to follow the example set them by designers of motor vehicles in employing heavier distillates as their fuel. For these undoubtedly a "poor" mixture would be preferable to effect complete vaporization. At the same time, I would like to draw attention to one phenomenon to which to my mind sufficient attention has not yet been given by designers of air-gas plant, and that is the creation of hydrocarbon "fog" in the gas. I believe it should be possible to disperse minute liquid particles of hydrocarbons evenly throughout the body of gas, and carry them along through a fairly extended system of piping without condensation, although they would not be "vaporized" in the strict sense of the word. The pertinacity of tar fog in effecting deposition in gas manufacture should serve as a good example in this direction. If suitable devices for intentionally creating such a fog would be constructed, even the use of hydrocarbons of the lamp oil type could be considered for air-gas purposes.

Dr. H. Swabacher (*communicated*): I trust that Mr. Scott-Snell will agree with me that, given an efficient machine, the next important thing is to enable consumers to use a cheap fuel, for preference motor spirit of approximately ·720 specific gravity This petrol is suggested for general use for two reasons: first, that this petrol is most suitable for motor-cars so that the owner of an air-gas machine and motor-car will not have to store two sorts of spirit; and, secondly, and this applies especially to the export trade, this petrol is obtainable in countries where neither the lighter spirit (*i.e.*, ·680 sp. gr.) nor the heavier spirit (*i.e.*, ·760 sp. gr.) are procurable.

Mr. Scott-Snell contends that it is not worth while to construct a machine to use the motor spirit, on the ground that, owing to the loss due to condensation, the extraneous heat required to assist evaporation (generated by the hot-air engine used as motive power), and waste spirit rejected by the carburettor, no economy is shown in the use of motor spirit, as against the light and far more expensive spirit of ·680 sp. gr. I question this statement. I would like to ask Mr. Scott-Snell whether this assertion made by him is based on theoretical considerations, or whether he has had practical experiments carried out on two efficient machines side by side; or, in turn, on one and the same machine capable of using either of the above-mentioned petrols. My personal experience of experiments carried out with at least one make in actual

practice (and not using one burner only, or an installation where one-sixth of a gallon only per night is used) is that a very great saving is shown, and this is not in one case, but a large number of installations where petrol of both densities has been employed. I fully agree with Mr. Scott-Snell's statements with regard to the condensation; this does take place to a slight extent when the heavier grade spirit is used, but where does the great objection lie compared with the economy? Condensation frequently takes place where coal-gas is used, in which case provision is made for the same. Surely it is a very simple matter to adopt similar precautions in the case of "petrol air-gas."

Coming to the question of the "rich mixture," say 5 per cent, which Mr. Scott-Snell so strongly advocates, as against the "poor mixture" of about 1½ per cent, Mr. Scott-Snell told us that he had always set his face against the use of the latter on the grounds of danger. This argument in favour of the "rich mixture" does not seem to me a strong one. In the case of the "poor mixture" the simplest forms of a stationary backflash resister eliminates all danger where this gas is used. On the other hand, if a "rich mixture" is in use, and a bad leakage in a small room or enclosure occurs, and any one approaches with a naked light, results may prove extremely serious.

Further, if condensation were such a serious objection to the use of motor spirit—the use of which I reiterate is, in view of the high price of petrol, of the gravest importance for the progress of the petrol air-gas industry—then the "rich mixture" would result in such serious condensation as would render the use of the same impossible.

Fortunately, experience has proved that, in practice, working on a "poor mixture" with ordinary motor spirit—

(*a*) All danger can be entirely obliterated.

(*b*) Great economy can be shown over any other form of artificial lighting.

(*c*) Highly successful results obtained.

Mr. H. Elwell-Smith (*communicated*): I wish to keep off technicalities as much as possible, so that the man-in-the-street can readily follow the discussion, as a considerable number are interested in this subject beyond the few technical experts principally connected with the manufacturing trade, and also to avoid controversial discussion relating to the merit or demerit of various makes now on the market.

I wish to admit beforehand that I am an advocate of what the author of the article terms "a rich mixture," although these memos. may infer the contrary.

In dealing with the efficiency of the light, however, I have certainly found that the smaller the percentage of hydrocarbons used in a mixture the more efficient is the light—when dealing within a range of from 1½ to 10 per cent vapour to the mixture. Therefore, in fairness, there is something to be said for those firms who advocate the 1½ per cent mixture. Mr. Scott-Snell did admit, however, that hydrocarbons of a heavy density could more readily be vaporized and held in suspension at a low percentage than at a higher one.

It would be of immense benefit to many to have published tables of the minimum temperatures of air and the percentages of the vapour at which hydrocarbons of various densities can be maintained without condensation, and a curve plotted on these lines would be greatly appreciated.

At present we have only Prof. Smith's temperature table of a spirit of ·663 specific gravity, and which I think I recollect is published in one of Sir Boverton Redwood's treatises. This is of little practical use to the outsider, as the generality of plants now in the market specify the use of petrols from ·680 to ·760 sp. gr.

There has been, and still is, great controversy theoretically between the safety of air-gas containing varying percentages of hydrocarbon vapour. Taking the matter on a practical footing, I have been called upon many times to inspect and report on generators of different types, and have found in many instances machines (some now of obsolete type) of which the percentage of vapour was between 2 and 3 per cent, or within the explosive

zone, the instructions for running these machines being in general to adjust the mixture until a blue flame was obtained. These generators were, in most cases, protected by a gauze box in the main pipe, and yet, in spite of the claims of all firms respecting the great necessity for keeping out of this explosive zone, it is an actual fact that never, in my experience, in a single case has an accident occurred inside the house on one of the systems working in the explosive zone, although, through external causes, several accidents have happened to the machines.

I certainly do not agree with the author's remarks that the candle-power is not appreciably affected by the pressure; considerably greater efficiency can be obtained, but the foot-lbs., or energy required, to maintain a pressure of, say, 8 in. (water column) would, in a weight-driven machine, be almost prohibitive.

Two well-known firms—Messrs. Keith Blackman and Messrs. Suggs—use large mantles only on their high-pressure systems, and within the last few years have increased their high-pressure gas from 8 in. to as high as 60 in. pressure.

With an 8½-in. pressure I have obtained from an ordinary Bray gas burner (upright pattern) 13·500 candles from the gallon of petrol. This is considerably greater than that obtained from the bijou at low pressure. Mr. Scott-Snell evidently has forgotten to take into account the large proportional number of heat units absorbed unnecessarily by the metal parts of many small burners as compared with one large unit. As, however, air-gas is principally used in domestic houses, and where the best distribution of light is essential, small units most certainly are advisable.

Re Motive Power.—The author touches on weight and hot-air engine-driven generators, but no attention appears to have been directed to the domestic water supply as motive power. This is by far the simplest form where a pressure supply is available, and is, in my opinion, the ideal power, the necessary foot-lbs. being easily obtained with a very small expenditure of water.

The amount of water used on a fifty-light installation for 120 lighting hours, with a good water pressure, would be about 40 gallons, and even if paid for by water at 1*s.* per 1,000 gallons would cost less than 1*d.* per 1,000 cubic feet of gas.

In combination with a water-driven generator a large petrol storage tank may be used, and light can be provided literally for months without attention, reasonable care being taken to protect the water pipes from frost.

It seems a pity some information *re* village and small town lighting by air-gas was not given by Mr. Scott-Snell. Although a photograph of a village lit by acetylene was shown, there was no mention made by the exhibitor as to whether or no this has proved a financial success—*the crucial point.* We all know acetylene gives a good light.

The first air-gas village lighting plant in the British Isles, I believe, was Harthill, Midlothian, installed by the writer in 1906. The company having paid a dividend steadily since its inception shows there is a successful future for schemes of this description, providing (as Mr. Scott-Snell states) the generating plant is well designed and efficient.

Mr. John Darch (*communicated*): I desire to express my thanks to the authors of the two papers, and particularly to the author of 'Petrol Air-Gas Lighting,' for the well-reasoned statements and valuable particulars given. Unfortunately for this form of lighting, while there are excellent "systems," there are too many contrivances that are unreliable, and the public, unable to distinguish one method from another, is under an impression that this form of lighting is not yet ripe for adoption. The patent laws are the barrier to progress, and until some of the patents expire we cannot expect air-gas lighting to go ahead.

The paper on 'Acetylene Lighting' is very comprehensive, and does not need an expert to understand it. As an architect I have no commercial interest in any form of lighting, and have, in practice,

found acetylene to be a satisfactory illuminant; but I must take exception to the statement here made, and elsewhere extensively advertised, that the colour of the acetylene flame is "pure white," and that "it approaches very closely to that of daylight." The exhibition of coloured photographs, taken under acetylene light, was in itself a sufficient refutation of that statement; for while the reds and yellows were brilliant enough, the greens and purples were grey or black. Let us, however, turn to an investigation by Dr. Voege, the results of which were contributed to the Society's Journal* but five months ago, and from which I select the following, based on a daylight (cloudy sky) standard and taking yellow-green (the most luminous part of the spectrum) as unity:—

	Blue	Green	Yellow Green	Red.
Daylight (average)	1·00	1·00	1·00	1·00
Acetylene	·27	·86	1·00	1·37
Electric Arc (ordinary)	·75	·97	1·00	1·35
Do (white flame)	1·05	1·21	1·00	1·68

Note the large falling-off in the blue element in acetylene.

I might also refer to the researches of Dr. Ives,† who, in this case, takes the spectral primaries, with red as a basis of comparison:—

	Red	Green	Blue
Average daylight	100	100	100
Acetylene flame	100	50	10·4

This indicates an even greater brownness of acetylene as against daylight. Surely it is time for acetylene lighting firms to eliminate this legend from their propaganda.

Another questionable statement is that acetylene is "perfectly clean and does not discolour walls and ceilings," and "even delicate decorations are not affected by it." Acetylene is a hydrocarbon with over 90 per cent of the latter element, and unless the flame be thin and otherwise in perfect order free carbon and CO will escape; indeed, it is doubtful whether absolutely perfect combustion is possible under ordinary circumstances. Mr. Butterfield, in his book 'Acetylene,' p. 6, says: "Since, per unit of light, acetylene emits a far smaller quantity of combustion products and a far smaller amount of heat than any other flame illuminant, except incandescent coal-gas, the inevitable black mark over its flame takes very much longer to appear [than coal-gas flames]."

When Mr. Hoddle turns to discuss intrinsic brilliance, he discounts all he has said before in saying that "the acetylene flame has only a mild luminosity, so that it can be gazed upon without the eye being conscious of any discomfort"; and yet Mr. Hoddle claims (in his catalogue) a power of 30 candles in the small flame area of a ½-ft. burner. Vivian Lewes, Rideal Butterfield, and other writers on acetylene do not appear to deal with its intrinsic brilliancy, and I had hoped that Mr. Hoddle would have favoured us with figures rather than general statements.

Acetylene is a good light, and will recommend itself. To over-rate it is but to court dissatisfaction from the public and smiles from the expert.

Mr. A. E. Cohen (*communicated*).—I claim the hospitality of your columns to dispute the contention of Mr. Scott-Snell that "there is probably no vast gain from the use of heavier spirit" than the 0·680 petrol used by him.

He himself quotes 1*s.* 9*d.* per gallon for 0·680 petrol, and states that there is no saving by using a cheaper petrol—merely because the carburettor may reject a small percentage of residue, or there may be a certain amount of condensation!

Having manufactured and supplied a large number of machines to evaporate 0·680 petrol, and having since, as a result of prolonged experiments by experts, put in a large number of installations using both 0·720 commercial motor spirit and 0·760 petrol, I am prepared to give any of your readers, on demand, the names of unbiased consumers who will testify to running costs with the lower grade petrol which no machine using the light spirit can attain; and, what is more, I have converted machines formerly using up every drop of the 0·680 spirit on a poorer

* *Illum. Eng.*, vol. v. p. 379.

† *Illum. Eng.*, vol. i. p. 1021.

mixture to use 0·720 petrol, running them on the same load for a prolonged period, and have shown a saving which would probably astonish the author of the paper.

Seeing, therefore, that there are innumerable installations running on the low-grade petrol, and showing economic results, I think that Mr. Scott-Snell's contention cannot be justified—especially when it is remembered that motor spirit is 5*d.* per gallon, or at least 25 per cent, cheaper than the spirit he is using.

Mr. J. S. Dow (*communicated*).—The discussion seems to have turned largely on one point—the comparative advantages of a "rich" and "poor" mixture. This is doubtless a vital one to the makers of petrol air plant. But one would like to have heard more as to the use of the illuminant. Little has been said as to the design of special shades and reflectors, or combinations of burners and reflectors to form one "unit," such as are customary in connexion with gas and electric lighting. The use of a rightly designed reflector is often quite as important a feature as the illuminant itself in promoting economy, and a petrol air or acetylene concern that devoted itself to the illuminating engineering side of the work should reap the benefit. At present there is an impression that petrol air-gas is mainly useful for country house lighting, and this is partly because the variety of units available is so restricted.

Mr. Scott-Snell has adopted a figure for the cost of petrol air-gas lighting considerably in excess of that claimed in catalogue literature. The question of the *average* as compared with the *initial* candle-power given by mantles ought surely to be reckoned in such calculations; no data were presented on this point.

Another point to be noted is the distribution of light from the burner. The small mantle used with petrol air-gas is approximately spherical, and I find that the horizontal candle-power is not far removed from the mean hemispherical candle-power (but naturally more than the mean spherical candle-power). In the case of acetylene, it is clear that the candle-power in a horizontal direction perpendicular to the plane of the flame (which, one may assume, is that generally quoted in catalogue literature) will be considerably more than in other directions. In order to include an estimate of the light in *all* directions comparison should be based on mean spherical candle-power.

I am glad that Mr. Darch has raised the question of resemblance to daylight. So many contradictory claims of this kind have been made on behalf of acetylene and petrol air-gas that it is high time authoritative tests were made. At the same time, it is at least open to doubt whether "artificial daylight" is desirable for ordinary illumination, however useful it may be for special work. Claims are also made from time to time to the effect that this or the other illuminant "contains no ultra-violet light." I have even met a case in which "richness in ultra-violet light" was claimed as an advantage.

Mr. Hoddle in reply said that he was glad Mr. Butterfield confirmed his impression as to mantles not being a success with acetylene; the chief trouble was that the orifices were so small that quite a little bit of dust would block them, and this upset the whole mixture.

But this did not apply to stoves, because the consumption was here so much greater. With a burner the consumption would be about $\frac{1}{4}$ cubic foot per hour, with a stove as much as 4 cubic feet; and the orifices were proportionally bigger. There were on the market some very useful and efficient acetylene stoves.

With regard to Mr. Liberty's comment, he thought it probable that the lamps he saw were acetylene flares, which, as Mr. Thorn had mentioned, were being largely used for road-construction work by the L.C.C., and had proved very economical. Mr. Thorn had given some data as to the cost compared with the old oil lamps, and some particulars as to the consumption and candle-power of such lamps would

also be found in his (Mr. Hoddle's) paper.

With reference to Mr. Pinnock's remark to the effect that petrol air-gas must be some good, else why are acetylene firms taking it up, to his knowledge those firms who have taken it up are doing so simply to be in a position to demonstrate the advantages and disadvantages of both systems.

As regards Mr. Darch's remarks, it was not, of course, claimed that acetylene was *identical* with daylight, but the contention that it closely resembles it is quite just, and is fully borne out by experience. In this matter it is probably better to trust to practical work in delicate colour operations rather than solely to such spectroscopic investigations as those of Dr. Voege, which, he understood, utilized certain colour-screens and a method which was apt to give particularly unreliable results in the blue owing to the low luminosity.

As regards the question of intrinsic brilliancy, it appears misleading to compare, as Mr. Darch apparently does, an acetylene flame with a filament or mantle. It may be that the intrinsic brilliancy of a low-pressure mantle (*i.e.*, the candle-power divided by the mantle area) works out to a value not far removed from the acetylene flame treated by this method. But it must be remembered that in the acetylene flame the brightness is uniformly distributed over the minute suspended particles; it does not consist of isolated intensely brilliant strands. In practice, very few people would object to the luminosity of an acetylene flame.

Mr. Scott-Snell (*in reply*): Having had the communicated remarks submitted to me since the meeting, I would point out that, with a few exceptions, they bear on the relative values of rich and poor mixtures. I can answer them *en masse* by pointing out that poor mixtures with heavy spirit, although showing a certain economy—which I have pointed out already in the paper—obtains this advantage at the expense of having to use explosive mixtures and gases near the saturation point at quite normal temperatures. A point lost sight of is that if a carburettor is rejecting any petrol at all, it becomes in effect a "surface" carburettor, and surface carburettors most emphatically are not to be depended upon for constancy of mixture with varying temperatures and velocities due to varying loads. I would also point out that the County plant can be changed to a "poor" mixture plant in one minute by the aid of a screwdriver; in fact, a well-known firm of gas stove makers uses a County plant for testing its petrol gas stoves, because it can be set at once for any particular "make" of gas. I can, therefore, claim to be unbiased in my opinions by commercial considerations. It is quite true that explosive gases can be stored with safety if proper precautions are taken; but so can gunpowder! Nevertheless, I should always feel "nervy" about an installation using an explosive mixture, as I have learnt respect for the power of petrol from an ocular demonstration.

Dr. Lessing suggests the use of heavy spirit in the form of "fog." I do not think this is feasible, as the gas in the pipes is often in a static condition, which would encourage deposition. I am certain, too, that he would find nipples becoming choked with drops of moisture. I know that fog is most difficult to eliminate *entirely*, but I know from experience with steam injectors for air-compressing that drops form on small orifices, however well designed the condenser may be. That petrol gas plant designers should follow the example set by motor designers seems to me very bad advice, since the conditions of use of the fuel are so widely different.

Dr. Swabacher states that condensation with coal-gas is not very important, and suggests analogy. Whilst granting him his hypothesis, I disagree with his conclusion. The effect upon the calorific value of petrol gas by condensation is vastly greater than the effect of condensation on coal-gas, since if the same number of B.Th.U.'s are lost per cubic foot in each case, the percentage number of B.Th.U.'s lost is very much greater in the latter case. For instance,

condensation from a simple gas (of one ingredient only, say, acetylene, if such could be imagined possible for the sake of argument) would not alter the calorific value at all. I am afraid space is too limited to make this as clear as I should like, but I hope Dr. Schwabacher will understand my meaning.

Mr. Elwell Smith deplores the lack of information on village lighting. I can only plead lack of space and time to go into it. For the sake of others who may have found the paper incomplete, I would point out that the paper had to be cut down in order to be read in twenty minutes to share the evening with another author.

Mr. Cohen would have been more convincing had he produced actual figures, instead of offering us the names and addresses of users who would testify for him.

The Lighting of Engineering Works by Gas, Oil (Incandescent), and Electricity.

An Interesting Discussion at a Meeting of the Manchester Association of Engineers, on January 25, 1913.

At this meeting the enterprising step was taken of inviting papers on the lighting of engineering workshops by three different illuminants. Gas Lighting was dealt with by Mr. Franklin Thorp, Electric Lighting by Mr. Haydn T. Harrison, and Incandescent Oil Lighting by Mr. J. E. Evered; and the papers were followed by a joint discussion.

A special problem was also set, so as to provide a common ground for the three illuminants, namely, to light a workshop consisting of two large bays each 250 ft. long, 50 ft. broad, and 30 ft. high, and three small bays each 250 ft. long, 30 ft. broad, and 15 ft. high, with an illumination on the working plane of not less than 1·5 foot-candles.

In what follows we give an abstract of the three papers.

The Lighting of Engineering Works by Gas.

By Mr. Franklin Thorp.

The lighting of engineering works has not until lately received the consideration that its importance merits, but I hope to demonstrate the value of modern gas lighting for this purpose. This is perhaps a fitting occasion to mention that the gas engineer welcomes the advent of the comparatively new publication *The Illuminating Engineer*. This monthly paper is devoting its pages to the study and review of lighting problems from all sources of light, and it is to be hoped that by maintaining an impartial attitude it will enable us to get at the true value of the various illuminants.

I cannot do better than quote from the December issue of this journal some simple rules for good lighting.

1. Don't work in a flickering light.
2. Don't expose the eyes to unshaded lights in the direct range of vision.
3. Don't judge illumination by the brightness of the lamps.
4. Avoid excessive contrast.
5. Use the right type of globe, shade, or reflector.
6. Make sure that the illumination is sufficient.
7. Keep lamps, globes, and reflectors clean.
8. Make sure that the lamps are in the right position.

There are, of course, many ways of treating the lighting of engineering

workshops, and much depends on the various tools used and the class of work carried on.

As a practical engineer myself, and

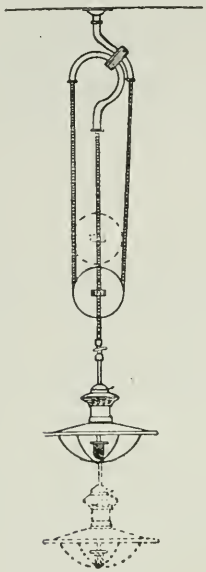


Fig. 1.

being interested as director or consultant in various works and mills in Lancashire, I am a firm advocate of giving plenty of light, knowing that the increased production and superior

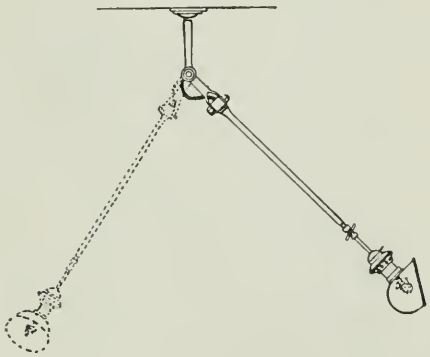


Fig. 2.

quality of work done more than pays for the cost of extra illumination.

Whilst I quite agree with 1½ foot-candles proposed as a basis, it will be noticed that I have shown a much greater illumination.

For the purpose of this paper we may take an efficiency of 50 candles per cubic foot of gas consumed, which is quite attainable in practice. Higher results have, however, been obtained in the laboratory, and the possibilities of still further improvements in gas lighting are still almost unlimited.

Turning to the problem before us, I would suggest that the cost of lighting two large bays and three small bays suggested would not exceed £225.

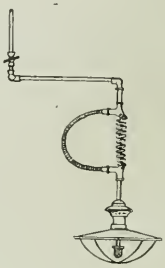


Fig. 3.

This cost includes :—

Compressors, governors, to 30,000 c.-p.

Fifteen–1,000 c.-p. h.p. Newbigging Thorp lamps, 16 ft. high.

Four–1,000 c.-p. l.p. Graetzin Lamps, 35 ft. high.

One hundred–100 c.-p. h.p. Textile Lamps.

Twenty-five rise and fall pendants, Fig. 1.

Twenty-five universal joint pendants, Fig. 2.

Fifty anti-vibrating joint pendants, Fig. 3.

All the necessary piping, taps, ironwork, and labour in fixing.

The compressors and governors are specially constructed to supply a constant mixture of about 90 per cent gas and 10 per cent air at a constant pressure to the lamps. The percentage of air can, however, be varied at will by turning a screw.

Any variation in quality or composition of gas which might affect the efficiency of a lamp can be corrected by adjusting a screw at the compressor, and this at once sets all the installation perfect.

These lamps will be arranged as shown in Fig. 5. The fifteen high-pressure lamps will be placed at a height of 14 ft. to 16 ft., and the four low-pressure 1,000 c.-p. lamps will be 35 ft. wide, well above the travelling crane.

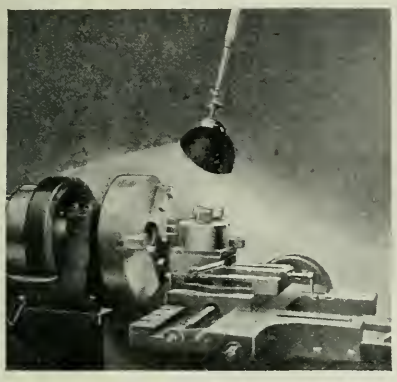


Fig. 4.

The illumination over almost the entire floor-space will exceed 1·5 foot-candles. Fig. 6 is a section showing the distribution of illumination down the centre of one of the bays.

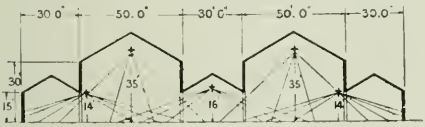


Fig. 5.

In passing, it may be mentioned that until recently there was one difficulty in connexion with incandescent gas lighting for factories, namely, that the light could not be readily applied in the position required. The special

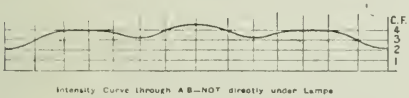


Fig. 6.

arrangements shown in Figs. 1–3 show how this adjustability can now be obtained, and Fig. 4 shows the method of concentrating the light on the work and screening the workmen's eyes.

The following are the approximate maintenance costs of the lamps employed. As mentioned previously, the illumination is considerably in excess of the $1\frac{1}{2}$ foot-candles specified; indeed, if one were to keep rigidly to this value the gas-consumption would be about halved:—

	Cost per Hour.
	d.
Cost of gas for a total candle power of 29,000 candles at 2*s.* per 1,000 ft., plus allowances for 4 bye-passes to low-pressure lamps	14·6
Large mantles—life average, 103 hours	1·5
Small mantles—life average, 300 hours	1·0
Silica chimneys on big lamps only ...	·1
Compressing from main shaft, ½ H.P. ...	·5
Attention, repairs, and cleaning	1·0
	18·7

Maintenance cost 1*s.* $6\frac{3}{4}$*d.* per working hour for 29,000 candles.

In conclusion, it may be pointed out that the system of gas lighting employed provides great reliability and steadiness—an important point that has often been emphasized in *The Illuminating Engineer.*

In addition, ease of manipulation and adjustment can now be obtained, and a great range in candle-power is available. Also, as mentioned above, there is a possibility of still further improvements in the efficiency of gas lighting which could be introduced into this scheme with comparative ease.

Incandescent Oil Factory Lighting.

By J. E. Evered.

The question of factory lighting has already received much attention, and is likely to receive even more during the next few years, now that the consumer has so many different methods of illumination at his disposal. It was, therefore, a pleasure to receive an invitation to read a paper on 'Oil Lighting' before the Manchester Association of Engineers, and the method adopted—of inviting representatives of three different systems of lighting to contribute papers—seems an excellent one.

Good illumination is now regarded as an industrial necessity. Without proper lighting good work cannot be done; defective illumination reacts on

the health and spirits of employees, and leads to spoiled jobs. Statistics have also shown that the greatest number of accidents occur during the winter months, when artificial illumination is most freely used. There is no doubt, therefore, that good artificial illumination pays, and it may be mentioned that, in many cases, the annual cost of lighting bears a very small proportion to the wages bill—sometimes less than 1 per cent. The choice of an illuminant for factory lighting depends largely on the local conditions; such questions as the range of candle-power available, the trouble needed to keep lamps clean and in working order, and the convenience with which the light can be distributed throughout the room—all these are important factors. Every factory presents a different problem to be studied on its merits. Sometimes general illumination is needed; in other cases local illumination from well-shaded lamps. In other cases, again, when complicated machinery is to be illuminated, the light should be well distributed, so as to penetrate into every corner of the room. In judging whether the oil lighting of a workshop is adequate, recourse should be had to measurements of illumination at the actual spot where work is carried out. One-half to 1 foot-candle suffices to enable people to see their way about, but 2 to 4 foot-candles is nearly always needed for close work. Another point to be noted is, that the lamps should be suitably screened, or hung sufficiently high up to avoid anything in the nature of glare.

One great advantage of oil lighting is that it is portable and self-contained, and can be readily carried about from place to place. The old wick oil lamps required much attention, and only yielded about 800–1,000 c.-p.-hours per gallon of oil (costing about 8*d.*). A great step forward was made when the plan of using oil vapour with incandescent mantles was introduced. This method has been used in the Kitson system of lighting, the essential elements of which are—the lamp, the oil reservoir, and the tubing. The reservoir may be immediately connected to the lamp, or may be some distance away and connected by piping. It is filled one-third full of petroleum, and air is then pumped in; when the valve is opened, this air (at a pressure of 53–75 in.) forces the oil through pipes to the lamp. It is then admitted to a specially designed vaporizing chamber, and the vapour passes into the burner and brings the mantle to vivid incandescence. The initial lighting up of the lamp may be accomplished by igniting spirit, by gas, or by electrical ignition. The process only takes a few minutes, and the lamp then continues to generate and burn oil vapour automatically.

It will be observed that the system is pre-eminently safe; the pipes only contain oil, which cannot be set alight at ordinary temperatures, and is only brought to the inflammable state in the lamp itself. Lamps of this kind can be readily transferred from place to place, and are of special use for emergency work in railway yards, erecting buildings, road excavations, &c. It may be noted that when the lights are supplied from a central reservoir through pipes the space occupied is remarkably small. Thus a tank capable of giving 200,000 c.-p.-hours only occupies 10 square ft. Another advantage claimed for these incandescent oil lamps is the bright, penetrating power of the light. This has been found very serviceable for lighthouse work, and is likewise useful for workshops and foundries where there is much steam or smoke. The latest form of lamp using inverted mantles will burn for 100–150 hours without attention, and (with the larger types of lamp) as much as 14,000 c.-p.-hours can be obtained from 1 gallon of oil.

The cost in general works out to well under 1*d.* per 1,000 c.-p.-hours, and three practical examples, including a shipyard, machine shop, and large engineering works are quoted in support of this figure.

In conclusion, the problem of lighting two large bays in a machine shop, each 250 ft. long, 50 ft. broad, and 30 ft. high, is next considered. It is suggested that, for this purpose, two sets of light 1,000 c.-p. lamps are to be

FIG. 1.—Central suspension of lamps.

FIG. 2.—Lamps suspended on both sides of bag on adjustable brackets.

used in each bay. These will be hung on brackets from the sides of the room, giving an illumination of 3–5 foot-candles. The running cost of the thirty-two lamps required for the two large bays should not be more than 3*s*. per hour. The initial cost of supplying the lamps, piping, and everything necessary will probably not exceed £225.

In the same way the three small bays, each 250 ft. long, 30 ft. broad, and 15 ft. high, are considered, and it is shown that the same illumination could be provided in each bay by a series of eight lamps hung down the centre of the room. The running cost for the three bays should not exceed 2*s*. per hour, and the cost of installation (twenty-four lamps in all) should not be more than £170.

The Illumination of Engineering Workshops by Electricity.

By Haydn T. Harrison.

The work carried out in a modern engineering workshop has to be of a very accurate nature. This means that every detail of the work should be clearly visible to the worker, and that any defects in lighting such as might cause strain on the nervous system should be carefully avoided. Glaring lamps must therefore be absent; engineers now adopt methods which make it impossible for the eye to see the filament under general conditions. It must be borne in mind that the position of tools in a workshop has naturally a bearing on the system of lighting selected; the electrical driving and the resultant absence of shafting and belting, often simplifies the lighting problem considerably, &c.

As regards the intensity of illumination desirable there is at present much difference in the practice adopted, even in factories of the same class. This is illustrated in Mr. D. R. Wilson's admirable series of tests included in the last Annual Report of the Chief Inspector of Factories. It is evident that the amount of light required is to some extent dependent on the reflected power of the materials worked with. The following figures might perhaps be taken as essential in machine shop working in America :—

General Illumination in addition to local lighting	1·5	ft. candles
Bench " "	4	"
Machine " "	6·7	"
Foundries, general Illumination	3	"
Power Houses " " ...	2·5	"

An important point emphasized in Mr. Wilson's report is the necessity for avoiding "glare." The chief points to be borne in mind are (1) position of the light unit and (2) the necessity for efficient shading. It is difficult to reduce the intrinsic brilliancy of illuminants down to $2\frac{1}{2}$ c.-p. per square inch without undue absorption of light, and it is therefore becoming general to adopt a system by which none of the light sources are visible, except those used for general lighting which may have a comparatively low intrinsic brilliancy.

The general illumination given in the figures presented above was put at 1·5 foot-candles, and this has been suggested as a basis for the lighting of the workshop suggested.

The large bays being 30 ft. high, it is evident that bright lamps, placed at a level out of the direct range of vision, can readily be used. The width of the building is 50 ft. It may therefore be suggested that the line of lamps placed down the centre of the room should be spaced at this distance. Five modern flame arc lamps will be employed, and these can be conveniently run in series on 200 to 240 volts. Practice has proved that 500 watt lamps will give the requisite candle-power to produce 1·5 foot-candles midway between the lamps. The cost of lighting for 1,000 hours would work out as follows :—

	£	s.	d.
(a) 2,500 Board of Trade Units at 1*d*.	£10	8	4
(b) Carbons and trimming at ·3*d*. per lamp hour	6	5	0
(c) Interest and sinking fund and repairs...	7	10	0
Total for 1,000 hours	£24	3	4

Total cost of lighting per bay per hour 5·8*d*.

In the small machinery bay, where the height is only 15 ft., shaded tungsten lamps are preferably used, and these may be spaced a distance apart equal to about twice the height of the lamps

above the working plane. If the lamps were placed 13 ft. above the floor, *i.e.*, 10 ft. above the working plane, each lamp will serve to illuminate an area of 400 square feet; twenty such fittings would be required, and would give the desired illumination. The running cost would work out as follows:

1,000 Board of Trade units at 1*d.* ...	£4	3	4
Lamp renewals	2	10	0
Interest, sinking fund, and repairs ...	3	0	0
Total per 1,000 hours	£9	13	4

At this point it may be of interest to summarize the conditions of lighting in the two bays:—

LARGE BAY (12,500 sq. ft. floor area):—

Efficiency of lamps in required direction	5 C.P. per watt
Total candle-power allowed	12,500 C.P.
Candle-power per sq. ft.	1·
Cost per sq. ft. per 1,000 hours	·464*d.*

SMALL BAY (7,500 sq. ft. floor area):—

Efficiency of light sources	2 C.P. per watt
Total effective light allowed	2,000 C.P.
Candle-power per sq. ft.	·267
Cost per sq. ft. 1,000 hours	·31*d*

It may be remarked that in prescribing the illumination in a factory it is often necessary to have special reference to the number of men at work, and to see that each individual worker receives the required illumination. The writer has found that in general about 10 watts per man should be provided, as well as a small amount for general lighting in the room. This is all that is necessary, provided that suitable efficient opaque reflectors are used.

Possibly the cost of electric lighting assumed, namely, 1*d.* per unit, may be considered rather low, but as most large works have either got their own generating machinery or are supplied by power companies it will be found that this is a fair average. There can be no doubt that adequate illumination pays. Statistics have been obtained and published showing that defective illumination is often responsible for the increase in output varying from 12 to 20 per cent, and in this paper it has been shown that by the proper use of electrical lamps efficient illumination can be very economically obtained.

Lectures on Illuminating Engineering at the Polytechnic (Regent Street, W.).

On Friday, January 17th, Dr. W. Ettles delivered the opening lecture of the new year on 'Illumination and the Eye.' A variety of lantern slides was thrown on the screen illustrating the structure of the eye, its sensitiveness to light, the action of the muscles controlling the lens and the iris diaphragm, and the complexity of the human retina. A special feature was a series of slides which could be manipulated by hand in order to show how the pupil aperture altered whenever there was an effort of accommodation. In conclusion, the lecturer pointed out how acuteness of vision was affected by the chromatic aberration of the eye, which was usually incapable of focussing violet rays; this was a fact that should be born in mind by those who attempted to study the "detail-revealing" power of coloured light.

On Friday, January 24th, Mr. J. S. Dow dealt with the 'Measurement of Light and Illumination.' The early part of the lecture was devoted mainly to an explanation of the terms commonly used in connexion with illumination (candle-power, illumination, flux of light, &c.).

Subsequently he passed on to standards of light, and explained the working of an ordinary photometric bench. He pointed out also the importance of studying the distribution of light in all directions, and described the use of the Ulbricht globe to determine mean spherical candle-power.

A considerable portion of the lecture was devoted to illumination photometers. The Holophane Lumeter, Lightometer, and Luxometer were shown and described. As examples of the work that could be done with such instruments he referred to the measurements in schools, libraries, &c., presented at meetings of the Illuminating Engineering Society, and to the series of 2,500 measurements made in over one hunderd different factories, undertaken for the Home Office by Mr. D. R. Wilson.

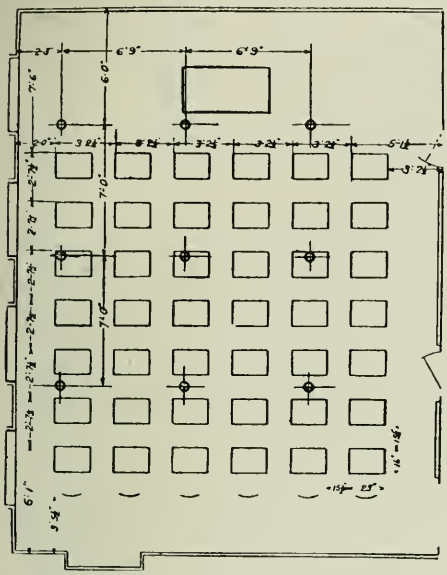
The Illumination of Schoolrooms.

What is needed nowadays is to induce the general public, as well as the lighting engineer, to take an interest in illumination. It is, therefore, a good sign when one finds the general Press include articles dealing with the subject, and especially so when a journal devoted to a certain trade or profession takes up the particular aspect of lighting that interests its readers. A case in point is provided by *The American School Board Journal* for June of this year, which contains an article by Mr. V. R. Lansingh on the 'Illumination of School Buildings.'

Mr. Lansingh gives particulars of the tests carried out by the Committee of Boston oculists and electrical engineers, working in conjunction with Mr. B. Hatch, the engineer for the School Buildings Commission in that city, in 1907. This seems to have been one of the first joint investigations on schoolroom lighting. The standard classroom in the United States is stated to be from 24–26 ft. in width, 28–30 ft. long, and 13–14 ft. high. The Committee considered quite a number of different schemes, with a view to getting the best general conditions of lighting, aiming chiefly at the avoidance of glare, the provision of a sufficiently strong and even illumination for the desks and blackboard, and the avoidance of inconvenient shadows. The scheme ultimately preferred, known as the "Nine Point Method," is shown diagrammatically in Fig. 2, while Fig. 1 is a photograph of a room arranged on this plan. In this case Holophane reflectors and tungsten lamps were used, but presumably good results could also be obtained with inverted incandescent mantles, if the correct reflectors were used and the same positions for the lamps adopted.

In this scheme the centre of the distribution of light is located slightly

in front and to the left of the centre of the desk area. This arrangement casts the dominant shadows towards the right and the rear. The scheme has been widely copied in schools in other cities in the United States, such as Newark (N.J.), Rochester (N.Y.), and New York City.



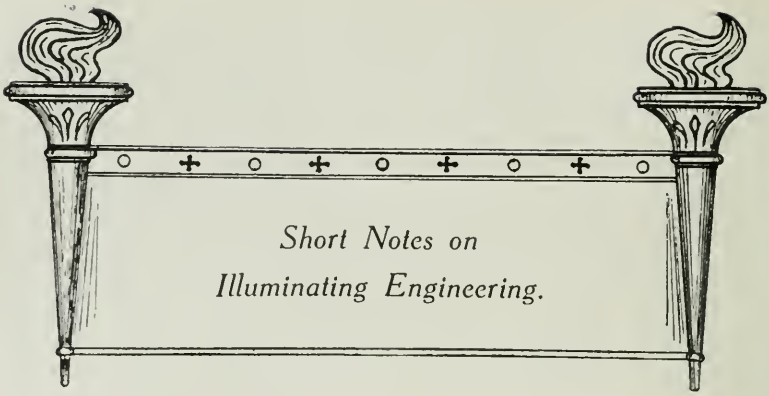
Commenting on the other schemes investigated by the Committee, Mr. Lansingh says :—

"Special methods of artificial illumination have been tried from time to time : for instance, the method of lighting entirely from one side of the room, and, again, by an indirect fixture throwing all the light to the ceiling and upper side-walls, whence it is reflected to the working plane. The first method was tried in St. Louis, use being made of strongly concentrating prismatic glass reflectors arranged in the angle between ceiling and side-wall at the left of the room above the windows. This approximated daylight conditions, but was not entirely successful. The indirect method of lighting has certain inherent objections, so that up to the present time it has found little favour. However, with the recent improvements in lamps and reflectors, it is quite probable that this method, or better, a modification having a slight direct element (known as the semi-indirect method) will find limited application where the conditions are favourable to its use."

Another point that received attention is the colour of the walls and ceilings ; in Boston light-green walls (reflecting about 46 per cent of the light) and buff ceilings (reflecting about 51 per cent) have been used. In other instances the buff and tan combination has been used with success, but light green seems to be regarded as, on the whole, the best tint. The coefficient of reflection is in general fairly high, and the colour is considered to produce a restful impression.

The British Departmental Committee on Industrial Illumination.

The Home Secretary has appointed a Committee to inquire and report as to the conditions necessary for the adequate and suitable lighting (natural and artificial) of factories and workshops, having regard to the nature of the work carried on, the protection of the eyesight of the persons employed, and the various forms of illumination. The Committee are : Dr. R. T. Glazebrook, C.B., F.R.S., Director of the National Physical Larboratory (Chairman) ; Mr. Leon Gaster, Prof. Francis Gotch, D.Sc., F.R.S., Mr. J. Herbert Parsons, M.B., D.Sc., F.R.C.S., Mr. W. C. D Whetham, F.R.S., and Sir Arthur Whitelegge, K.C.B., Chief Inspector of Factories. The Secretaries of the Committee are : Mr. D. R. Wilson, one of his Majesty's Inspectors of Factories, and Mr. C. G. Paterson, M.I.M.E., A.M.I.C.E., of the National Physical Laboratory. Any communications regarding the inquiry may be addressed to Mr. D. R. Wilson at the Home Office.



MODERN METHODS OF ELECTRIC WIRING.

BESIDES understanding the conditions governing good illumination, a specialist in electric lighting installations should be thoroughly familiar with modern methods of wiring.

An excellent paper on this subject was read by Mr. Frank Broadbent before the Association of Engineers-in-Charge on December 11th. Mr. Broadbent traced the development of the series and parallel systems from 1874, and showed how the latter method developed into the "tree" and "distribution" systems. He also dealt with jointing and looping, calculation of size of conductors, types of cable and tubing, earthing, and many other debatable matters.

We commend it to the notice of those desiring a concise account of the chief points to be considered in modern electric wiring.

DO NOT READ IN BED.

FEW people realize (says *The Academy*) how pernicious is the habit of reading in bed. It is said to be a fertile source of colds and sore throats, and is also injurious to the eyes; even a portable, well-shaded electric lamp does not always obviate the possibility of defects of vision being developed in this way. All conditions are sacrificed to the desire for a comfortable posture of the body, with the result that a bad position for reading is frequently adopted. Moreover, most people already use their eyes too much for close work during the daytime; they should, therefore, be cautious in continuing the strain by night.

It need not be said that reading in bed by the light from an open flame is dangerous. Many fatal accidents have arisen through the reader dropping off to sleep and leaving an insecurely placed light burning.

ILLUMINATING ENGINEERING IN AUSTRALIA.

PAPERS on lighting and illumination are now being delivered all over the globe.

We notice that Mr. J. Eck, who will be well known to readers as a member of the Council of the Illuminating Engineering Society, and who is paying a visit to Australia, delivered a lecture on 'Indirect Arc Lighting' before the Victorian Institute of Electrical Engineers in Melbourne, on December 3rd, 1912.

It is interesting to observe that our friends in Australia are also not without enterprise in matters connected with illumination.

FIRELIGHT AND ELECTRIC LIGHT.

These two photographs, which were shown at a recent meeting of the Illuminating Engineering Society by Messrs. Dow and Mackinney, illustrate the very striking difference between the old illumination and the new—firelight and electric light.

The first photograph shows the flickering, badly distributed, but yet "cosy" illumination from a banked-up coal fire. The second photograph was taken in a room lighted by a tungsten lamp and Holophane semi-indirect unit. The diffusion of the light in all directions, making reading quite easy in any part of the room, is in marked contrast with the firelight.

Our modern strenuous life, requiring us to read, work, and entertain in the evening, demands an order of illumination vastly greater than that accepted a generation ago, when people were content to rest and chat round the fireside.

Fig. 1.—Cosy illumination from a banked-up coal fire.

Fig. 2.—Room lighted by Tungsten lamp and Holophane semi-indirect unit.

PHOTOGRAPHS BY ACETYLENE LIGHT.

As is well known, it is no easy matter to take snapshots by artificial light, or even portraits, for which a comparatively long exposure is allowed. This is partly due to the lower actinic power of artificial light as compared with daylight, and partly to the fact that the brightness of daylight is, as a rule, incomparably greater.

Some examples of such photographs taken by electric light are given above. The accompanying illustration is of a group taken at night by the light of an acetylene flare. Another snapshot by acetylene was given in Mr. Hoddle's recent paper (p. 73) before the Illuminating Engineering Society.

Snapshot taken at night by the light of an acetylene flare.

Review of the Technical Press.

ILLUMINATION AND PHOTOMETRY.

A number of journals celebrate the new year by publishing general articles on the development of **Illumination during 1912.** The contribution by L. B. MARKS on this subject (*Elec. World*, Jan. 4) refers to the development of interest in factory lighting on the part of authorities and the probability of forthcoming legislation on this point. He also points to the formation of a German Illuminating Society as one of the most important events during the year. The *Zeitschrift für Beleuchtungswesen* (Jan. 10) has also a readable contribution on progress in illuminants. P. S. MILLAR, in a recent paper before the National Electric Light Association, deals with lighting problems in a general way, and adopts an ingenious method of demonstrating the distinction between good and bad lighting. He prepares a series of boxes, and fits them up with toy furniture, miniature light units, and even dolls, to represent figures engaged in reading and writing. In this way the chief characteristics of direct, indirect, and semi-indirect lighting can be readily shown, and the right and wrong positions for reading demonstrated.

Good Lighting contains several interesting illustrated articles. That by GODINEZ deals with the **Lighting of the Home** in a popular fashion. Another contribution describes a collection of old lamps and lighting appliances in Dresden.

KAJET (*Licht und Lampe*, Dec. 19) discusses various kinds of searchlight lamps for **Illuminating Building Work by Night**; he also illustrates various modern types of high candle-power street lighting fittings which contain several tungsten lamps in the same lantern.

Turning next to **Photometry**, we may note the general survey by IVES (*Elec. World*, Jan. 4), who regards the vindication of the value of the flicker photometer for comparing lights of different colours as one of the most interesting events. It may be noted, however, that the author's results still await confirmation by other observers. H. KRÜSS (*Z.f.B.*, Dec. 30) describes a number of new forms of photometers, including a form of Lummer-Brodhun equipped for binocular vision. He also describes a variation of the ordinary rotating sector device. If the sector is rotated, there is always the difficulty that it is inconvenient to adjust the exposed aperture exactly while the apparatus is in motion. Krüss therefore keeps the sector still, and rotates the beam of light by means of a couple of Fresnel prisms.

Finally, reference may be made to the study, by Blondel and Rey (*T.I.E.S.*, Nov., 1912), of the time taken to perceive lights of short duration—a problem that has an important bearing on the observation of distant flashing lights at sea.

ELECTRIC LIGHTING.

There is little to record in this section. P. S. MILLAR contributes a general summary of progress (*Elec. World*, Jan. 4), and there is a similar article in *The Electrical Review and Western Electrician*. A. LEDERER contributes an unusually complete study of the **Tungsten Lamp**, the underlying physical phenomena and the possibilities of improvement in the future (*Elek. u. Masch.*, Dec. 29). *The Électricien* for Jan. 18th contains an account of a new form of small carbon filament lamp, with a specially shaped mirrored bulb for producing a very concentrated beam. *The Electrical Review and Western Electrician* deals with electric hotel lighting, the great majority of examples given being by indirect methods.

GAS, OIL, AND ACETYLENE LIGHTING.

C. R. BOND (*Am. Gaslight Journal*, Dec. 30) has prepared the usual annual review for the American Gas Institute of the **Photometry of Gas Lamps.** An interesting preliminary item is their classification according to candle-power. He also makes suggestions as to how the

results of tests should be tabulated and arranged.

W. ZACHERT (*J.f.G.*, Jan. 4, 11) discusses the phenomena underlying the highly efficient incandescent lamps of to-day. The chief point on which he lays stress is the importance of a short, condensed flame, better results being almost invariably obtained with small, compact mantles. STAVORINUS (*J.f.G.*, Dec. 28) describes the work of a firm in Arnheim responsible for the design of artistic and imitation antique gas fittings. Old French and Dutch designs and candles can be successfully copied, and a special form of piping in the form of a square chain is much employed.

Among other events of interest we may note the announcement of the formation of a **petrol air-gas association,** by the aid of which it is hoped more trustworthy data regarding the performances of petrol air-gas plants will be collected.

List of References:—

ILLUMINATION AND PHOTOMETRY.

Blondel, A. and Rey, J. — The Perception of Lights of Short Duration at their Range Limits (*T.I.E.S.*, Nov. 1912).
Editorial. — Illumination (*J.G.L.*, Dec. 31, 1912).
Godinez, L. — The Light of the Home (*Good Lighting*, Dec. 1912).
Ives, H. E. — Progress in Photometry (*Elec. World*, Jan. 4).
Kajet, A. — Licht und Lampe für nachtliche Bauausführungen (*Licht u. Lampe*, Dec. 19, 1912.)
Krüss, H. — Neue Photometrische Apparate (*Z. f. B.* Dec. 30, 1912).
Marks, L. B. — Tendencies in Illuminating Engineering (*Elec. World*, Jan. 4).
Millar, P. S. — Some Phases of the Illumination of Interiors (Paper read before the National Electric Light Association, U.S.A., *Good Lighting*, Dec. 1912).
Thomas, S. A. — Artificial Lighting of New York City Public Schools (*Good Lighting*, Dec. 1912).
Illuminating Bodies and Lamps from Ancient Times (*Good Lighting*, Dec. 1912.)
Principles of Industrial Lighting (*Engineering*, Jan.).
Das Beleuchtungswesen im Jahre 1912 (*Z. f. B*, Jan. 10).

ELECTRIC LIGHTING.

Bloch, L. — Electric Light in Competition with other Systems (*A.E.G. Zeitschr.* Dec. 1912).
Broadbent, F. — Modern Methods of Electric Wiring (Paper read before the Association of Engineers in Charge).
Lederer, A. — Die Wolframlampe und ihre Entwicklung unter Berücksichtigung der letzten Verbesserungen (*Elek. u. Masch.* Dec. 29).
Millar, P. S. — Developments in Electric Lighting (*Elec. World*, Jan. 4).
Lampe Speciale pour publicité lumineuse et Illuminations (Électricien, Jan 18).
Progress in Electric Lighting and Illuminating Engineering (*Elec. Rev. N.Y.* Jan. 4).
Electricity in Hotel Service (*Elec. Rev.* and *Western Electrician* Nov. 21, 1912).

GAS, OIL, AND ACETYLENE LIGHTING.

Böhm, C. R. — The Manufacture of Mantles for Incandescent Lighting (*J.G.L.*, Jan. 7, 14).
Bond, C. R. — The Photometry of Incandescent Gaslamps (*Am. Gaslight Journal*, Dec. 30).
Editorial. — Government Officials and Gaslighting (*J.G.L.*, Jan 7).
Othmer — Unsere Aufgaben in den Kleinwohnungen (*J.f.G.*, Dec. 28).
Stavorinus, D. — Alte Beleuchtungskörper in neuzeitlicher Fassung (*J.f.G.*, Dec. 28).
Zachert, W. — Uber neuere Brenner und Lampenkonstruktion (*J.f.G.*, Jan. 4, 11).
A Shadowless Lamp-carrier (*J.G.L.*, Dec. 31, 1912).
Fortschritte in der Glühlampentechnik (*Z.f.B.*, Jan. 10).
A Petrol Air Gas Association (*Domestic Engineering*, Jan. 17).

CONTRACTIONS USED.

E. T. Z.—*Elektrotechnische Zeitschrift.*
Elek. u. Masch.—*Elektrotechnik und Maschinenbau.*
G. W.—*Gas World.*
J. f. G.—*Journal für Gasbeleuchtung*
J. G. L.—*Journal of Gaslighting.*
T.I.E.S.—*Transactions of the Illuminating Engineering Society* (*U.S.A.*).
Z. f. B.—*Zeitschrift für Beleuchtungswesen.*

WANTED.

TWO 12 IN. TO 16 IN. ELECTRIC SEARCHLIGHTS FOR YACHT. Mangin Lenses required. Must be in good working order. Write Box 166, T. B. Browne's Advertising Offices, 163, Queen Victoria Street, London.

REVIEWS OF BOOKS.

The Science of Illumination. By Dr. L. Bloch. Translated by W. C. Clinton, B.Sc., A.M.I.E.E. (John Murray, 1912, 6/ net.)

Mr. W. C. Clinton has undertaken a translation of Dr. Bloch's well-known work ('Grundzüge der Beleuchtungstechnik'), also bringing the book up to date by the addition of supplementary information on events that have taken place since its first appearance.

The translation has been undertaken in a painstaking manner, and the book has also gained in value for English readers by the added matter relating to information published in this country, and making the work less strictly Continental in its scope.

The contents of Dr. Bloch's book will be familiar to readers of this Journal. The first chapter deals with fundamental units, and in chap. ii. a useful and up-to-date summary of methods of determining mean spherical candle-power is given. Calculations of illumination are next dealt with somewhat fully, some serviceable examples of estimates of indoor and outdoor illumination being reproduced. The chapter on illumination photometers is considerably extended, reference being made to Trotter's well-known work and to various forms of instruments recently introduced in this country. Street lighting measurements receive special attention, and it may be noted, in view of the discussion now taking place on this subject, that measurement of horizontal illumination is advocated. The tabular data based on actual indoor and outdoor installations are particularly useful.

Indirect lighting receives a special chapter. Very little information is available relating to calculations for indirect installations, and the formulæ given by Dr. Bloch for estimating surface brightness and the influence of reflecting power of walls and ceilings deserve study; here again there is some valuable tabulated data referring to gas and electric indirect lighting installations in Germany.

The Appendix contains a series of concise tables, values of illumination being expressed side by side in lux and foot-candles.

Some Publications Received.

Transactions of the Institution of Gas Engineers (1912).—As usual, this contains an interesting variety of papers. There is, however, not much connected with illumination.

Proceedings of the Physical Society of London (Vol. XXIV. Part VI.) contains a number of papers read at the joint meeting with the Optical Convention last June. Many of these deal with light and illumination.

Report of the British Association for the Advancement of Science on the Influence of School-Books upon Eyesight—Makes a number of recommendations as to hygienic requirements with which school-books should conform. A typographical table is given containing specimens of the type recommended for the use of children of different ages.

Le Choix d'un Eclairage dans les petites Villes et à la Campagne: Lettres à un Ami.—A very ingenious booklet containing "correspondence" on private-house lighting, and advocating the claims of acetylene.

Abstract-Bulletin of the Physical Laboratory of the National Electric Lamp Association (Cleveland, Ohio, U.S.A.).—This is the first volume issued under the supervision of Dr. E. P. Hyde, and contains a variety of papers on the scientific aspects of photometry and illumination, previously published in various journals, and now collected together.

Colour and Light in relation to Miners' Nystagmus. By Dr. H. S. Elworthy, F.R.C.S. (Reprinted from *The Ophthalmoscope.*)

Colour Adaptation, by Dr. F. W. Edridge Green, M.D., F.R.C.S. Paper read before the Royal Society, January 23rd, 1913.

Notice of the Fifty-Fifth Course of Lectures and Demonstrations for Sanitary Officers of the Royal Sanitary Institute.—A very comprehensive course, but we observe that illumination is apparently not included in the Syllabus.

TRADE NOTES.

[At the request of many of our readers we are extending the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

Street Lighting Progress in Farnworth.

During the last two months the electric lighting of the main streets in Farnworth has been undergoing complete alterations. After exhaustive tests and experiments, it has been decided to adopt two 300 c.-p. Osram drawn-wire lamps of 220 volts, in place of each of the 10-ampere arc lamps formerly used, and to fix them to the same poles by mean of a two-armed bracket having a projection of some 36 in. from the pole, and being fastened to it by cast-iron clamps.

The lamps are now arranged at a height of 20 ft., centre of the lamp to ground. The Osram lamps used are provided with suitable reflectors. The whole lighting scheme has been designed by Mr. Hutchinson, the engineer, and the lamps and fittings have been supplied by the Manchester branch of **The General Electric Co., Ltd.** All the former feeders have been utilized. The switches in connexion with the new system are of Messrs. Dorman & Smith's manufacture. The new illumination has proved to be highly efficient in every respect, and the lighting problem of this town has been solved—for some time, at least.

Change of Address.

From January 1st, 1913, the business of Norden's & General Incandescent Co., Ltd., has been acquired by, and transferred to, **The New Sunlight Incandescent Co. (1900), Ltd.,** of 344, Gray's Inn Road, King's Cross, London, W.C., who now carry on the same, and execute all pending and future orders from the above address.

All outstanding accounts due may be sent either to this address or to the New Sunlight Co. direct.

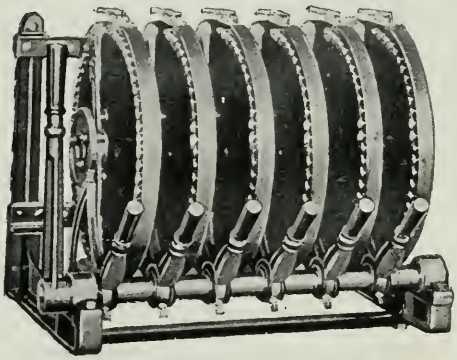
"Alabas" Bowls for Semi-Indirect Lighting.

One of the latest types of semi-indirect lighting introduced by the British Thomson-Houston Co. is by means of "Alabas" bowls, some examples of which are shown in the illustration.

A variety of these units are on view at the Company's showrooms. Unlighted, they appear as if cut out of solid blocks of Italian marble; when lighted, they appear equally and mildly luminous all over, giving a most charming effect, and yet being a most efficient form of semi-indirect lighting.

B.T.H. Theatre Dimmers.

The figure shows one of the B.T.H. metallic theatre dimmers. Ordinary liquid dimmers require constant attention and are costly to maintain; metallic resistances, besides being more compact, work more smoothly and noiselessly, and require less attention than liquid ones.



The B.T.H. dimmer can be operated very easily, even by a novice. They are built up in standard plates, somewhat like an adjustable bookcase, and can be made in two distinct types—to mount either flat against, or at right angles to, the switchboard.

Fuller information can be obtained from the **British Thomson-Houston Co.**, Lamp and Wiring Supplies Department, Mazda House, 77, Upper Thames Street, E.C.

Mazda Lamps for Stage Lighting Unrehearsed Vibration Tests.

From theatre dimmers to Mazda lamps for stage lighting is a natural transition. It is reported that, at the Theatre Royal, Elephant and Castle, an iron frame containing eighty-eight drawn-wire lamps was accidentally allowed to drop about 10 ft. Yet only one bulb and seven filaments were broken. A somewhat similar accident occurred a few months ago at the Prince of Wales's Theatre—the only difference was that in this case *no* lamps were injured.

Yet another stage department in which the British Thomson-Houston Co. is interested is the use of arc lamps for the production of scenic effects; for this purpose the B.T.H. LENS arc lamps are exceptionally suited.

"Ruralux" Petrol Air-Gas Plant.

We have received an attractively got-up pamphlet describing the "RURALUX" Petrol Air-Gas System (**Petrol Gas Plant & Engineering Co.**, 19, Marsham Street, Westminster, S.W.). The illustrations are distinctly effective.

The plant is claimed to be exceptionally compact, and it is added that the richness of the gas can be adjusted so that either 800 or 1,200 cubic feet of gas can be made from 1 gallon of petrol.

It is interesting, in view of the discussion elsewhere in this number, to note that light petrol is used: "For although by artificially heating the carburettor it may be possible to use a somewhat heavier spirit, there is a tendency for the heavier hydrocarbons to condense in the pipes, especially during cold weather."

We note that vertical, inverted, and "horizontal inverted" burners are all listed, inverted burners giving from 20–100 c.-p. being available.

Messrs. Falk, Stadelmann & Co., Ltd. (83–87, Farringdon Road, London, E.C.). —Catalogue of Fittings and Accessories for petrol air-gas, comprising brackets, candelabras, pendants, table standards, &c.

There is no doubt that the apparatus for distributing the light from petrol air-gas mantles is an important item—sometimes even as much so as the light itself. Not only the utility of a light, but the impression as to its artistic appearance depends very greatly on the form of shade or fixture employed. Any one interested can obtain a copy of this list, free, on application.

Battersea Polytechnic.

Lectures on Electric Lighting and Illumination.

A COURSE of lectures—to take place on Wednesdays, 8.30–9.30 P.M.—on this subject, by Prof. A. W. Ashton, commenced at Battersea Polytechnic on Jan. 15th. The course deals with electric illuminants, measurements of light, and illumination in general.

This course is suitable for students who have already taken the second year (Part I.) Course of Electrical Engineering, or have a sufficient knowledge of the subjects included in that course. The lectures will be found to be extremely useful to all engaged on the "lighting" side of electrical engineering.

Further particulars can be obtained from the Secretary, Mr. J. Harwood.

The ILLUMINATING ENGINEER
ELECTRICITY · ACETYLENE · OIL · GAS
Edited by LEON GASTER

THE JOURNAL OF SCIENTIFIC
ILLUMINATION.
OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London, 1909.)

ILLUMINATING ENGINEERING PUBLISHING COMPANY, LTD.
PUBLISHING OFFICES :—ATHENÆUM PRESS 13, BREAM'S BUILDINGS, LONDON, E.C.
Tel. No. 2120 Central.
EDITORIAL OFFICES :—32, VICTORIA STREET, LONDON, S.W.
Tel. No. 5215 Victoria.

EDITORIAL.

The Annual Dinner of the Illuminating Engineering Society.

An account of the Annual Dinner of the Illuminating Engineering Society held on Monday, February 10th, will be found on pp. 155–161.

It only needs to be said that the dinner was highly successful, and that the occasion served to mark the growing vitality and influence of the Society. The attendance showed a considerable increase over that at the dinner in 1912, and the Society was fortunate in securing the presence of a number of distinguished guests.

The appointment by the Home Secretary of a special Committee on Industrial Lighting was naturally the subject of frequent reference, and Sir Arthur Whitelegge (H.M. Chief Inspector of Factories), who was present as a guest, made a kindly reference to the value of the work our Society is doing.

Prof. Silvanus P. Thompson, in his reply to the toast of the "Illuminating Engineering Society," pointed out the great value of its international connexion. There are now in existence three Illuminating Engineering Societies in England, Germany, and the United States; and we expect to see similar bodies in other countries before long. Our relations with these societies are of a

most friendly nature, and provision has already been made for effective co-operation.

Illumination is a new subject, and will benefit immensely from international agreement in the early stages. Other and older professions than illuminating engineering are apt, when framing recommendations, to find themselves occasionally "up against" the dead weight of accumulated tradition. But in illuminating engineering we have still to formulate our rules and precepts, and we are therefore taking precautions to frame them in such a way as to meet requirements all the world over.

The Use of Shades and Reflectors.

The paper read by Messrs. J. G. Clark and V. H. Mackinney before the Illuminating Engineering Society on February 18th will be found on pp. 125–134.

The authors have wisely only attempted to cover the ground in a very general manner, stating the chief functions of shades and reflectors, and giving some examples of their use and misuse. This alone provided ample material for discussion.

In the relative importance attached by different speakers to the various functions of a shade in this discussion one could clearly trace the influence of individuality. Some people appear to regard a shade as serving the exclusive purpose of screening the newer sources of high intrinsic brilliancy from the eye. Others are chiefly struck by the value of shades and reflectors as a means of directing the light where it can be most usefully employed.

The truth usually lies midway between these two views. A properly designed reflector should answer both purposes. On the other hand, it will be conceded that in private house lighting, in the drawing-room, for example, the use of shades in order to soften the light and produce a restful effect, and as decorative objects, is probably more important than the question of economy; and so long as there is enough illumination in the room for ordinary purposes, we do not trouble if there is a certain loss of light as well. But in the lighting of offices, factories, banks, &c., the questions of efficiency and economy are all important, and the *directive power* of a reflector is one of its most valuable qualifications.

Reference is often made to the glaring effect of metallic filaments. We hold that incandescent mantles also require appropriate shading. But it will be admitted that the rapid development of metal filament lamps has led to a great many examples of bad shading, and for the following reason: a very large proportion of the shades at present in use were designed for use with the smaller sized carbon filament lamps. They were therefore quite unsuited to the much longer bulbs of metal filament

lamps, which projected out in an unsightly, not to say ludicrous manner. This instance only serves to illustrate the result of the present lack of co-operation between the manufacturers of shades and lamps respectively. Had there been proper co-operation from the start, much of the outcry against the glare of the metal filament lamps might have been avoided. The time is coming when the lamps and shade will be regarded as "one unit," and no one will consider the source of light to be employed without also thinking what form of shade he will use with it.

It need scarcely be said that only the fringe of this subject has been touched as yet. There are many complicated technical problems connected with the design of globes, shades, and reflectors, such as the absorbing and diffusing qualities of different materials employed in the manufacture of shades, the shaping of reflectors to give a certain distribution of light, &c., that have still to be considered. These will no doubt provide abundant material for discussion at future meetings of the Society.

Illumination and Miner's Nystagmus.

It will be recalled that in a recent number of this journal* we drew attention to a valuable paper by Dr. Llewellyn on the above subject. The general conclusions reached are in agreement with those reached by Dr. Ellworthy and reported at the Ophthalmic Congress at Oxford this year. In both cases statistical inquiries were supplemented by actual measurements of illumination in the mines examined, and it was found that nystagmus was apparently much more prevalent in those mines in which old-fashioned and inadequate forms of lamps were employed and the surroundings were exceptionally gloomy.

Dr. F. W. Edridge-Green (see p. 122) now comes forward with an explanation why this nervous disease of eyesight should be accentuated by poor illumination. It seems that at very feeble illumination the eye is in a state of unstable equilibrium. Fluctuations take place in the distribution of visual purple. The central region of the retina (under normal conditions the part where vision is most acute) is practically blind. This naturally leads to a more or less oblique method of looking at things, and the unstable condition of the retina is apt to give rise to a curious "wobling" sensation when an attempt is made to fix the gaze on any particular point. The important thing now seems to be to ascertain the minimum illumination needed in order to avoid these peculiar conditions. The researches of Dr. Llewellyn and Dr. Ellworthy have thrown valuable light on the subject, but some more precise recommendations seem to be needed. The problem is one that requires the joint efforts of the physiologist of the photometric expert.

* Dec., 1912, p. 540.

Two Important Forthcoming Meetings of the Illuminating Engineering Society.

On p. 124 will be found an official announcement of the subjects to be considered at the next two meetings of the Illuminating Engineering Society, which should be of exceptional interest.

On Tuesday, March 11th, Mr. W. J. Liberty will deliver a lecture dealing with the 'History of Gas Lighting in this country.' This subject was selected in view of the present year being officially celebrated as the centenary of gas supply, and the jubilee of the Institution of Gas Engineers. It is expected that the lecture will be accompanied by many illustrations and exhibits of historic interest. It is well now and then to pause and review progress in methods of lighting, the influence of which on the social progress of the century, has been most striking. The lecture, therefore, is one that should appeal strongly to members of our Society, and it is also naturally of special interest to the gas industry. The Society has therefore issued a special invitation to the members of the Institution of Gas Engineers to be present.

It will be recalled that the gas centenary is also to be celebrated by an exhibition to be held at Shepherd's Bush next October, and we understand that the treatment of illumination will form a special feature. We hope that all our gas members will take advantage of the occasion, and do their best to make this exhibition a successful and instructive one.

At the subsequent meeting to be held on April 15th a paper will be read by Mr. A. P. Trotter dealing with 'Standard Clauses to be included in a Specification of Street Lighting.' Readers are aware that this draft specification has been prepared by a joint committee representing the Illuminating Engineering Society, the Institutions of Gas and Electrical Engineers, and the Institution of County and Municipal Engineers, and the meeting on April 15th will be a joint meeting at which these various bodies will be represented.

When the committee was first formed the hope was expressed that the results of their labours might be discussed on the impartial platform afforded by the Illuminating Engineering Society. We desire to express our appreciation of the great compliment that has been paid to our Society in recognizing its platform as the most suitable for the purpose of bringing about a closer co-operation between the above-named bodies; and for arriving at a satisfactory solution of this most important question of the best methods of testing and specifying street lighting.

LEON GASTER.

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of 'The Illuminating Engineer.'

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

The Purkinje Effect and a Comparison of the Flicker and Equality of Brightness Photometers.

By M. Luckiesh.

With the increasing diversity of types of light sources the demand for a means of comparing lights of different colour is constantly growing. Recent investigations in heterochromatic photometry indicate the flicker photometer as the best means for such work, although there is not a complete agreement on some of the phenomena encountered when comparing lights of different colour. Dow* found the Purkinje effect to be less with the flicker method than with the equality of brightness method; while Ives† found a reversed Purkinje effect with the former method. Millar‡ in photometering a mercury arc against incandescent lamps reported that the former measured much brighter at lower illuminations than would be indicated if the inverse square law rigidly held. With the flicker method this effect was absent. It seemed of interest to test this point with a commercial flicker photometer at hand, and at the same time make comparisons with an equality of brightness photometer both with contrast and without. At the same time it was desirable to compare the sensibilities of the three methods. For this purpose a Marten's flicker photometer was chosen. A simple photometer which is fitted with contrast screens was chosen for the direct comparison of brightnesses. Both instruments were made by Schmidt and Haensch. The sources of light were tungsten lamps, and a red and a bluish-green screen were placed on the two sides of the photometer respectively. Two observers carried out parallel sets of observations throughout, the ordinary precautions being taken against prejudiced settings. The two observers checked identically with all three methods when balancing lights of the same colour.

The results are plotted on a scale of illumination which was calculated on the assumption that the red light obeyed the inverse square law. This, of course, is not true, but no better method presented itself, and the effect is merely to either elongate or telescope the scale somewhat at the low values of illumination. The values of illumination are those on the photometer screen, calculated from the value obtained at a high illumination, when the red light was balanced against a standard tungsten lamp by means of a flicker photometer. The actual illumination on the eye was of less importance, because commercial photometers were used without alteration, making it easy to reproduce the same conditions in practice. The field size, which is of vast importance in heterochromatic photometry, was practically the same in both photometers — about ten degrees. The field in the Marten's flicker photometer consists of an inner circle surrounded by a circular ring, while the shape of the field in the equality of brightness photometer was a circle divided vertically The contrast screens covered the upper and lower halves of the semicircles respectively. The ratio of the square of the distance of the "red" lamp from the flicker photometer screen to the square of the dis-

* Dow, *Phil. Mag.*, Jan., 1910, p. 58.

† Ives, *Phil. Mag.*, July, 1912, p. 149.

Millar, *Trans.* Ill. Eng. Soc., Nov., 1909, p. 179.

tance of the "green" lamp is plotted as ordinates in the two upper curves in Fig. 1 for the two observers. It is significant to note that the two observers checked identically when there was no colour difference. Observer K for a wide range of illuminations obtained a value for the ratio R/G, about 13 per cent higher than observer L, even with the flicker photometer. A pronounced reversed Purkinje effect was found for illuminations of the screen less than one meter candle. The lamp and screens were reversed to eliminate any instrumental errors. The values obtained after reversal are indicated by the crosses which show a close check. The same ratio calculated from the

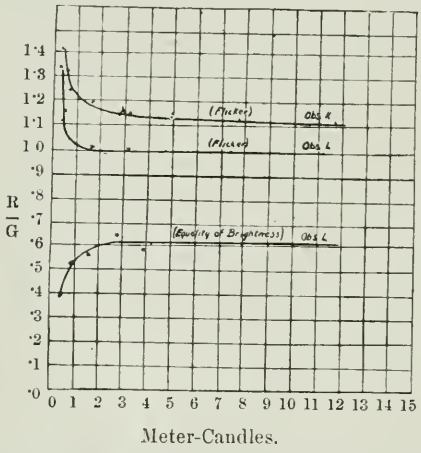


FIG. 1.—Purkinje effect and reversed Purkinje effect obtained by the equality of brightness and flicker methods respectively.

writer's data, obtained with the equality of brightness photometer, is plotted in the lower curve. The circles represent values obtained with a contrast field, while the dots represent the values obtained without contrast. It will be noted that there is a large difference between the values of the ratio R/G, obtained by observer L by the two methods. The values obtained by the equality of brightness method (which were practically the same with a contrast photometric field as without contrast) was, for a wide range of illuminations, only 62 per cent of the value obtained with the flicker photometer. This difference illustrates that although the flicker photometer offers a means of eliminating the disturbing influence of colour-difference, it does not measure the same quantity as measured by the equality of brightness photometer. The researches of Ives* show, however, that the flicker photometer which he used (a modification of the Whitman disc) is more desirable than the direct-comparison photometer. The equality of brightness observations by observer K on being plotted were found to be quite scattered, but indicated a real Purkinje effect. This observer was quite inexperienced in the photometry of lights of extreme colour-difference, while observer L has had considerable experience. The latter's data presented here checks with data previously obtained by him and presented by Ives in his extensive research in heterochromatic photometry. The difference in the flicker measurements by the two observers was first thought to be due to a different criterion in each case. That is, it was found that slightly different results were obtained with the flicker photometer used if flicker was made to disappear in the central field or in the surrounding peripheral ring. This was found to be so slight, however, that in no way could it account for the 13 per cent difference. The flicker on the outer ring was disturbing, and tended to cause difficulty in fixation of the eye on the central part of the field.

The sensibility of the three methods was next determined. The mean deviation from the mean was computed for the various points of observation. These are sufficiently regular or consistent for the flicker method as to bear plotting, and are therefore shown in Fig. 2. At an illumination of 10 meter candles on the photometer field the mean deviation from the mean for the writer was about 0·5 per cent. This rose to about 0·9 per cent for observer K. However, it is a point highly in favour of the flicker photometer that a comparison of a red light with a blue-green one can be made with such small mean deviation from the mean of a number of settings.

In the photometry of lights of different colour by the equality of brightness

* *Phil. Mag.*, 1912.

method the writer has always favoured a two-part field without contrast, but had previously made no determinations of the sensibility of the two methods. In the comparison of lights of such extreme colour difference as those used in this investigation there was no consistent change of sensibility with illumination, so that it seems legitimate to average the sensibilities computed at the various illuminations used. The average of the mean deviation from the mean of a large number of settings at each illumination was found for observer L to be 1·9 per cent and 1·6 per cent for photometric fields with and without contrast respectively. For observer K the sensibility was found to be 2·9 per cent and 3·3 per cent respectively, apparently being in favour

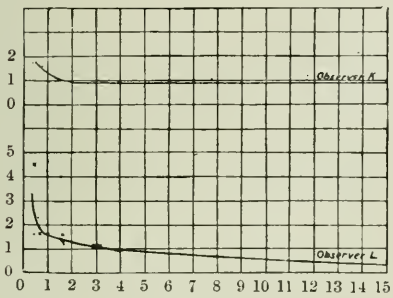


Fig. 2.—Sensibility of the Flicker Photometer.

of the field with contrast. But, owing to the inexperience of observer K, little weight can be given to this result. When there was no colour difference the flicker method at 15 meter candles gave results for observer L which sometimes indicated a sensibility as high as 0·2 per cent. Of course, under the condition of no colour-difference there is no reason to use the flicker photometer, because a sufficiently high sensibility can be obtained with the equality of brightness method.

Comparison of the red and blue-green lights on various days checked very closely by means of the flicker method. However, fairly close checks were made by the experienced observer from day to day with the equality of brightness method.

Summary.

When a red light was compared with a blue-green light, a pronounced reversed Purkinje effect was found by both observers with the flicker method for an illumination of the photometric screen less than one meter candle. The illumination at which the effect appears depends, of course, on the absorption of the optical parts of the photometer and the area of the artificial pupil.

A real Purkinje effect was found with the equality of brightness method. The same results were obtained with an equality of brightness photometer with and without a contrast field. The writer favours a photometric field without contrast where there is a colour difference, and found his sensibility higher when using such a field as compared with a contrast field.

With the flicker method one observer obtained the value of the ratio of R/G, when calculated according to the inverse squares of the distances of the red and blue-green lamps from the photometer screen, to be about 13 per cent higher than the value obtained by the other observer for an illumination of the photometer screen of 10 meter candles. Throughout the whole range of illuminations used (from 0·5 to 13 meter candles) a large difference between the two observers was obtained. The value of R/G obtained by observer L with the equality of brightness method was found to be only 62 per cent of its value by the flicker method at an illumination of approximately 10 meter candles. Observer K also obtained a lower value, which was 76 per cent of its value by the flicker method, and 87 per cent of the value obtained by observer L with the latter method.

The fact that the flicker method shows a reversed Purkinje effect seems to be established. While it is known that the two methods of photometry herein considered yield different results, the other data are presented here for the purpose of emphasizing this point.

The writer is indebted to Mr. Leonard Krill for valuable assistance in the experimental work.

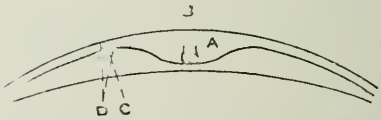
A Physiological Explanation of Miners' Nystagmus.

Dr. Edridge-Green makes an interesting suggestion as to the cause of miner's nystagmus. It appears that this defect is much more prevalent in dimly lighted mines, and the question arises why this should be so. Now the eye at a very weak illumination is known to be in quite a different state from what it is when the illumination is high. Its chief characteristic is that the centre of the eye (where there are only "cones") is, in certain circumstances, practically blind, whereas in bright daylight vision is most acute in this region. This difference appears to be due to the absence of the visual purple, in darkness, from the central area of the retina.

Yet it may be remarked that the provision of a certain illumination is not quite all that is required. According to Dr. H. S. Ellworthy, the nature of the surroundings in the mines has a lot to do with the matter; if these are very dark and gloomy even a strong illumination will not retrieve the situation. Dr. Ellworthy has kindly sent us two of his recent papers on the subject. He suggests that what is needed is to lighten the tint of the sombre surroundings in mines, and he adds that the absence of colour may also have something to do with the abnormal condition of the eye. However this may be, it is reasonable to suggest that the surface brightness of the surroundings is a most important item; and one would like to know what the minimum value in mines should really be.

Dr. Edridge-Green has shown that when there is no visual purple in the fovea,* this is conveyed there by stimulation in the surrounding portions of the retina by light *or by movement of the eye.* It will be readily understood how difficult it is to work in such a light as this. Persons constantly find it necessary to move their eyes in order to see things clearly. This movement brings the visual purple into the central region. Thus, if a chalk mark be made on a blackboard in a feebly lighted room, and be regarded intently, the eye will commence to move, or, if the eye be kept from moving, the chalk mark will disappear. If several other chalk marks be placed at a short distance from the first one, not only will the eye be less inclined to move, but the centre chalk mark will be seen much more clearly. This shows the value of a diffused light instead of a point source. Such conditions give rise to the nervous movements of the eyes known as nystagmus.

Diagram of Retina, showing distribution of rods and cones.



A. Space fitted with fluid sensitized by visual purple.
B, Space containing cones only.
C. Rods containing visual purple.
D. Cones.

The eye is in a very unstable condition, and the quantity of visual purple in the centre of the retina fluctuates, giving a distinctly curious "wobbling" impression when one tries to look fixedly at any object.

All these effects occur in very feeble illuminations (under one-tenth of a foot-candle, for example). The remedy is very simple. Increase the illumination above the margin where the activity of the centre of the eye becomes impaired. Here, again, one would like to have from physiologists data in terms which the lighting engineer can understand. Are they prepared to state what is the minimum illumination in foot-candles necessary to avoid this peculiar effect?

* Readers interested in this subject will be glad to know that three papers on the subject by W. F. Edridge-Green were published in the *Journal of Physiology* in November, 1910, July, 1911, and August, 1912, respectively.

TRANSACTIONS

OF

The Illuminating Engineering Society

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

The Use of Shades and Reflectors.

A MEETING of the Society was held at the house of the Royal Society of Arts at 8 P.M., on Tuesday, February 18th. The chair was taken by Mr. F. W. Goodenough, who, owing to an important engagement, was compelled to leave before the end of the meeting, his place being taken by Mr. F. Bailey.

The minutes of the last meeting having been taken as read, the names of the applicants for membership were presented in the usual way.

The Chairman then announced that, at the next meeting of the Society, on Tuesday, March 11th, a special lecture on the 'History of Gas Lighting in this Country' would be delivered by Mr. W. J. Liberty. A general invitation had been given to members of the Institution of Gas Engineers to be present, and any members of the gas industry who were interested would be welcome.

At the subsequent meeting, on Tuesday, April 15th, a paper dealing with Street Lighting would be presented by Mr. A. P. Trotter, and this would be made the occasion for a discussion of the basis of the Standard Specifications for Street Lighting. It was proposed to make this a joint meeting of the various societies interested, who, it was hoped, would send delegates to join in the discussion.

The Chairman then called upon Mr. J. G. Clark to read the paper presented by himself and Mr. Mackinney, entitled 'Some Notes on Shades and Reflectors.' The paper was illustrated by a number of slides, and some novel apparatus was exhibited showing the conditions of shadow produced respectively by direct and indirect illumination. An interesting discussion then ensued, in which the following took part :—

Mr. A. Blok, Mr. G. Campbell, Mr. A. Cunnington, Mr. J. Darch, Mr. Haydn T. Harrison, Prof. J. T. Morris, Mr. T. E. Ritchie, and Mr. H. C. Wheat.

The Chairman added that communications in writing had been received from Mr. C. C. Paterson, Mr. W. C. Clinton, and Mr. P. J. Waldram, who had expressed regret at inability to be present.

Mr. V. H. Mackinney briefly replied.

The Chairman moved a vote of thanks to the lecturers, which was carried unanimously. This terminated the proceedings, and most of those present adjourned to the library, where tea and coffee were provided.

New Members of the Society.

THE names of the applicants for membership, read out at the previous meeting on January 14th,* have now been formally announced for the second time, and these gentlemen were declared Members of the Illuminating Engineering Society. In addition, the names of the following gentlemen have been duly submitted and approved by the Council, and were read out by the Hon. Secretary at the meeting of the Society on February 18th :—

Ordinary Members.

Allen, E. *Mem.Inst.Gas Engineers.*	Vice-President of the Institution of Gas Engineers. The Liverpool United Gas Light Co., Duke Street, LIVERPOOL.
Bosenberg, A.	Fittings Manufacturer, 5/f. Serrestr., DRESDEN.
Douglas, W. D.	Assistant in the Department of Physics and Electrical Engineering, Dublin Royal College of Science, 20, Garville Avenue, Rathgar, DUBLIN.
Elwell-Smith, H.	Electrical and Petrol Air Gas Engineer, Director and Manager of Spenser's, Ltd., 53, South Molton Road, LONDON, W.
Huntley, R.	Works Manager to Metalite, Ltd., 49, Portland Street, DERBY.
Ryan, G.	Surveyor, Messrs. Ryan & Penfold, Wimbledon Park, LONDON, S.W.
Thorp, F.	Gas Engineer, Managing Director of Franklin Thorp & Co., Grasmere, Whitefield, near MANCHESTER.
Wisé, W. C.	P. E. Chappins & Co., 85, Fleet Street, LONDON, E.C.

* *Illum. Eng.*, LOND , Feb., 1913, p. 66.

The Illuminating Engineering Society.

(FOUNDED IN LONDON, 1909.)

OFFICIAL ANNOUNCEMENT OF NEXT TWO MEETINGS.

(To be held in the House of the Royal Society of Arts, 18, John Street, Adelphi, London.)

The History of Gas Lighting in England.

On **Tuesday, March 11th**, a lecture on this subject will be delivered by Mr. W. J. LIBERTY, Lighting Inspector to the City of London, in commemoration of the centenary of gas supply. It is expected that a number of illustrations and exhibits of historic interest will be shown. A general invitation to be present has been issued to members of the Institution of Gas Engineers, and others interested are invited to apply for tickets to the Hon. Secretary of the Illuminating Engineering Society.

Standard Clauses for a Specification of Street Lighting.

On **Tuesday, April 15th**, a paper on this subject will be presented by Mr. A. P. TROTTER at a joint meeting of the Illuminating Engineering Society, the Institution of Gas and Electrical Engineers, and the Institute of County and Municipal Engineers.

The paper will not be read, but merely briefly introduced by the author. Advance proofs will shortly be available, and can be obtained by those wishing to join in the discussion on application to the Hon. Secretary of the Illuminating Engineering Society (Mr. L. GASTER, 32, Victoria Street, London, S.W.).

Some Notes on the Use of Shades and Reflectors.

By J. G. Clark and V. H. Mackinney.

(Paper presented at a Meeting of the Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, on Tuesday, February 18th, at 8 p.m.)

ABSTRACT.

[The paper commences with some general remarks on the need for efficient shading and the choice of suitable methods of screening and directing light. The chief functions of a shade are analysed and the results given of a series of tests of the distribution of light from various shades and reflectors, with gas and electric light. Subsequently an account is given of some experiments on the shadows cast by various sources, and direct and indirect lighting are compared in this respect. Some new apparatus for this purpose is described and illustrated. In conclusion the appendices are added containing a brief account of four installations, illustrated by photographs taken entirely by artificial light. These are selected with a view to illustrating special points in shading.]

Introduction.

In bringing this paper before the Illuminating Engineering Society the authors are conscious that a full treatment of the design and use of shades and reflectors would be quite impossible within the space available. The art of shading, in its broadest sense, involves the application of a variety of scientific principles, including reflection, refraction, diffraction, and diffusion; and these in turn can be further subdivided. The subject is also complicated by physiological and psychological phenomena, which lend themselves to various interpretations, according to the individual taste. One person will abhor what another appreciates and for no very clear reason; conditions which strike one individual as attractive and artistic, to another appear quite the reverse.

Therefore, bearing in mind the practical ambitions of this Society, it seemed desirable to emphasize mainly the utilitarian aspects of the art of shading, as applied to illuminating engineering, and to restrict ourselves to a general review of some of the more important practical qualities that shades and reflectors should possess. We hope that the discussion will provide an opportunity for any omissions to be rectified, and we will subsequently endeavour to clear up any points that may require further explanation.

We may define illuminating engineering as the science of the efficient utilization of light. There are doubtless great possibilities in the direction of the *production of light*, yet it will surely be agreed that the *efficient utilization of existing light sources* is of more immediate importance. Light, as raw material, is cheap enough even now. The economic possibilities of using this light are, at least, as promising as any impending improvements in the methods of production; the latter is uncertain, whereas the former is certain.

The present methods of producing light are by no means costly; indeed, it would appear that strikingly bad examples of illumination are not infrequently due to the low cost of light; possibly, if light were more expensive, people would be more careful in husbanding it, and its abuses (which are not confined to any one illuminant) would be less common.

It might be suggested that a paper dealing with bad examples of lighting would form an interesting feature for a future meeting of the Society. We feel sure that no difficulty would be found in providing subject-matter, and from a full appreciation of what is wrong, we might get some very clear ideas of what is right. A discussion on this subject carried on in the right spirit would be highly interesting and profitable.

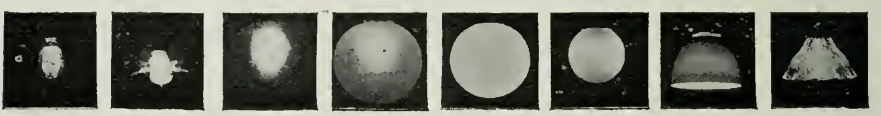
It is an old and well-worn saying that the industry that goes not forward, goes back, and it must have been

very clear to those who follow the interests of artificial illumination that this policy has found a lively appreciation on the part of many engaged in the design of lamps and lighting appliances.

One important point which has received very careful attention is that of maintenance and renewal of parts. It is part of the irony of things that "a look and a promise" are all that are given, and the results provide the bad examples. Recent improvements, however, have done much to minimize this.

Practical experience has provided the lighting engineer with much valuable information on illumination, and evidence of this having been turned to account may be found in modern

FIG. 1.—ELECTRIC UNITS.

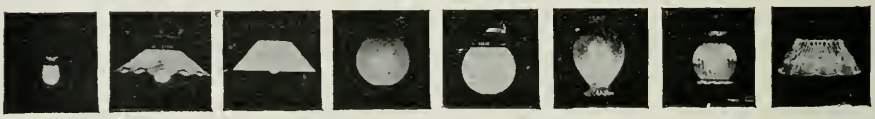


Close against black background.

Close against white background.

Illustrating apparent brightness of shade and modification of "glare" effect with change of background.

FIG. 2.—GAS UNITS.



Close against black background.

Close against white background.

Illustrating apparent brightness of shade and modification of "glare" effect with change of background.

whereas a consumer of light will pay almost elaborate attention to the trimming and charging of an oil lamp, he will regard the modern illuminant as self-maintaining, and while this is, no doubt, almost true, an occasional clean would often be a very profitable investment from an economic lighting point of view. In many cases, however, productions. Suitable robustness of construction, easy access to all vital parts, easy and cheap renewal of the wearing parts, and the use of suitable shades and reflectors are amongst the features that will be readily observed in modern lamp construction, and no doubt they have done much towards the maintenance of photometric efficiency.

It is interesting to note the increased interest taken by manufacturers of lighting appliances in the photometric performances of their productions. This can bring nothing but good results to the lighting industries, and as a natural consequence benefit the consumer both financially and hygienically.

The Objects of Shades and Reflectors.

The above remarks lead us to the consideration of the value of shades and reflectors as a means of modifying the distribution of light from illuminants, and so improving the practical utility of an installation. Some may perhaps consider our remarks on this subject rather elementary ; yet, judging from the examples one constantly meets with, it may well be suggested that these simple underlying principles need to be more widely known.

It is curious how seldom people seem to analyze what a shade or reflector is intended to do. In many cases the mere presence of a reflector appears to be all that is considered necessary. It is sometimes placed quite a distance away from the source, and the user apparently never realizes that, before a reflector can reflect light, light must fall upon it. It need scarcely be said that neither globe, shade, or reflector can *create light*, but is merely an aid in distributing it. (Some years ago an old gentleman called upon one of the authors, desiring to bring to his notice a method of "increasing the illuminating power of an ordinary source of light several fold." The scheme consisted in the use of a bull's eye in front of the light source. Naturally a bright image of the source was projected on the wall, and this, no doubt, suggested to him that the idea was worth developing.)

The main functions of a shade might perhaps be defined as follows :—

1. The screening of the source of light from the eye and avoidance of glare.

2. The direction of the light where it is chiefly needed (*e.g.*, reduced illumination of the upper parts of the walls and ceiling, and improved illumination on the working plane).

3. The softening and toning down of shadows.

4. Decorative effect.

All of which improve the visual value of the illuminant.

Of these the economical advantage of altering the distribution of light from a source so as to suit one's convenience is manifest. The lamps available at the present time admittedly differ enormously in this respect. Note, for example, the contrast in the light immediately below an upright and an inverted mantle ; and the difference in the directions of maximum candle-power from a metallic filament, flame arc lamp, or mercury vapour lamp. It is rare indeed that a source gives exactly the distribution of light required for a specific problem, and it is almost always necessary to use with it a suitable reflector. In many cases the maximum light is emitted horizontally, whereas in practice one usually requires the majority of the light to be directed downwards.

As showing how great are the advantages to be derived by using a suitable shade it may be well at this point to consider the distribution of light from an ordinary source enclosed in an opaque sphere. The whole of the light will then be intercepted by the envelope. The photometric value of the light included within any solid angle may be measured by the product of the candle-power, and the area of the sphere included within that angle. For instance if we divide the surface of the sphere by latitudinal lines corresponding to angular displacements of 10° above and below the horizontal (equator) we have the following figures representing the area of the respective zones* :—

---

* The figures are of course calculated from the following :—

$$\text{Let } A = \text{area of sphere}$$
$$\text{then } dA = 2\pi\nu^2 \operatorname{Cos}\theta.\, d\theta$$
$$\therefore\ A = 2\pi\nu^2 \int_{\theta_2}^{\theta_1} \operatorname{Cos}\theta.\, d\theta$$
$$= 2\pi\nu^2 \left[\operatorname{Sin}\theta. \right]_{\theta_2}^{\theta_1}$$
$$= 2\pi\nu^2(\operatorname{Sin}\theta_2 - \operatorname{Sin}\theta_1)$$

Angular displacement from equator.	*Relative Area.*
0 to 10°	1736
10° to 20°	1684
20° to 30°	1580
30° to 40°	1428
40° to 50°	1232
50° to 60°	1000
60° to 70°	737
70° to 80°	451
80° to 90°	152

These data are well known in connexion with calculations of spherical values, but they are also a great aid in studying the problem of reflection and distribution of light, and in deducing the probable advantages that may arise therefrom.

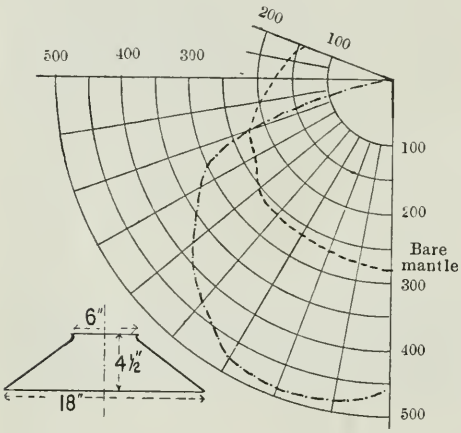


FIG. 3.—Distribution curve of incandescent mantle and mantle in enamelled steel reflector.

If we assume for a moment that the zonal distribution of the light source is equal in all directions, then the preceding figures would represent the proportional photometric values of the light included in the respective angles. They do not, of course, represent the utility values of the light, but they *do* indicate the amount of raw material available for use by the application of appropriate reflectors. If the candle-power distribution of a source was the same at all angles, the photometric value of the light emitted (the quantity of raw material) within the angle 0° to 10° would be 2·36 times that included within the angle 60° to 70°, *i.e.*, if we have 100 candles within the angle 0° to 10°, and could reflect the whole of it to the angular space within 60° to 70°, the loss to the former angle would be 100 candles, but the gain at the latter would be 236 candles. Of course, we cannot reflect with such a high degree of efficiency, but the practical advantage is fairly obvious. Figs. 3 and 4 show this effect in a practical way.

In the following notes it will, we hope, be shown that the immense advantages to be derived from the use of proper shades and reflectors would almost invariably permit of better illumination at a cheaper running cost, and that any expense incurred

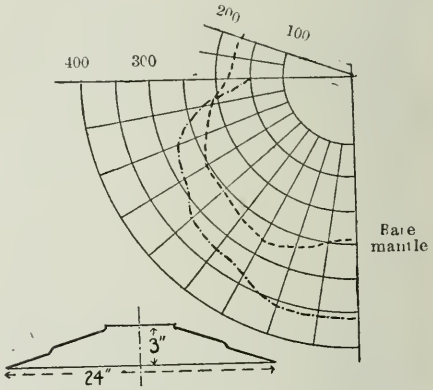


FIG. 4.—Distribution curve of incandescent mantle and mantle in enamelled steel reflector.

by the adoption of suitable reflectors is more than compensated for by the improved illumination.

Nature of Shades Available.

For our purposes any element used in conjunction with a source to achieve either or all of the objects named above might be termed a "shade." Shades may be divided into three great classes, *firstly*, those that are main reflecting; *secondly*, those whose chief purpose is to shade the light and tone down its brilliancy; and *thirdly*, those which diffuse and redirect a substantial portion of the light during transmission, and in so doing may direct it in some desired direction. The following table, without being exhaustive, seems to

comprise the chief varieties of shades in use :—

SHADES.	MATERIALS.
Opaque Reflecting.	Cardboard, Enamel Iron Green cased opal silvered glass.
Transparent Reflecting	Clear Glass with external Prisms.
Translucent Reflecting and Diffusing.	White or nearly white glass, including Opal.
Transparent Refracting and Diffusing.	Clear Glass with external and internal Prisms.
Diffracting (an effect intermediate between transparent and translucent.	Clear Glass, sand-blasted or acid etched.
Globe Form (those possessing the properties of diffusion or diffraction, and redirection).	Clear Glass with external and internal prisms. Opal, White or nearly White Glass. Clear Glass, sand-blasted or acid etched.

The variety of shade most suitable in practice naturally depends to a great extent on which of the four main functions suppression of glare, redirection of rays, softening of shadows and decorative effect are the more important. The first two considerations usually occur together. By the very fact of reflecting in a desired direction light which would otherwise pass out horizontally, we diminish glare. In providing general illumination one usually prefers a translucent shade which allows a certain amount of light to be transmitted out into the room, and so avoids excessive contrasts. For local lighting, on the other hand, when the shade is placed comparatively near to the worker's eye an opaque shade, completely covering the source, is usually desirable. The question may here be raised whether any minimum intrinsic brilliancy for shades should be prescribed. It will be recalled that the brightness of the sky (about 2–3 c.-p. per square inch) has been suggested, but some have contended that the figure should be even lower. It seems obvious, however that the value one would consider necessary will depend on the position of the light and its distance from the observer. The sensitiveness of individuals to brightness also seems to vary very greatly. Perhaps some expressions of opinion on this point will be forthcoming in the discussion.

In estimating the intrinsic brilliancy of translucent shades the uneven distribution of brightness is often a difficulty. The variety of conditions one may meet with in this respect is aptly illustrated in the series of photographs reproduced in Figs. 1 and 2, taken entirely by artificial light. People sometimes argue as if complete uniformity of brightness were the ideal, but it is obvious that this would considerably limit the possibilities of artistic treatment, and, as a matter of fact, people often prefer a mild "sparkle."

Another factor that has a material influence on the apparent brightness of a shade is *background*. In the figures this is illustrated by the various sources having been photographed first against a black, and secondly against a white cloth. In a photograph of this kind one naturally cannot reproduce the exact impression of the eye, owing to limitations of contrast; but the figures give an idea of what is meant. The bright portions of the shade and its edges are much less prominent when the background is white.

In lighting of a purely utilitarian character the redirection of light is a most important function. It leads to better illumination, and may also render possible economies. By introducing the right form of a reflector, sources of lower candle-power and smaller consumption may often be substituted, with an actual increase in illumination on the working plane.

There are, of course, also cases in which artistic appearance is everything, and the cost of comparatively small moment. It may then be legitimate to permit quite a large amount of light to be absorbed in the material of the shade (silk, alabaster, &c.) for the sake of ornamental effect. This is a branch of the subject which is necessarily omitted from this paper. But it may be said that the importance of the shade as a decorative object is not yet sufficiently recognized, and offers a vast field for the artist and the architect. At present one often sees noble and richly decorated interiors lighted by extremely tawdry and cheap

shades and fittings. It is a matter for wonder that the care bestowed on the architectural scheme of an interior so often stops short at the illumination.

Tests of Some Typical Shades and Reflectors.

As an illustration of the effects and advantages of various common forms of shades, we have reproduced in Figs. 3–20, a series of diagrams, each comprising the polar curve of light distribution from the bare source and the corresponding curve from the same source equipped with a certain form of shade or reflector. A rough sketch of this reflector is appended in each case.

Figs. 3–12 were obtained with incandescent mantles (upright or inverted), and Figs. 13–20 with an ordinary electric tungsten lamp.

The diagrams show the redistributing effects of certain reflectors which are in fairly common use, and are, as a rule, easily procurable.

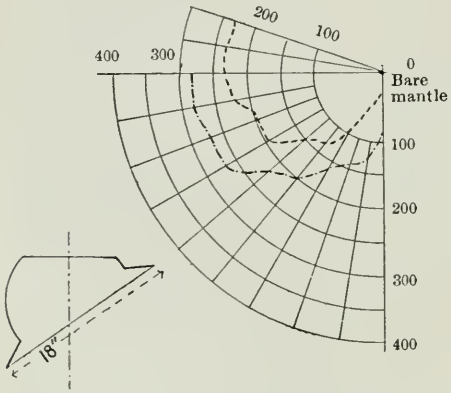


FIG. 5.—Distribution curve of incandescent mantle and mantle in enamelled steel reflector.

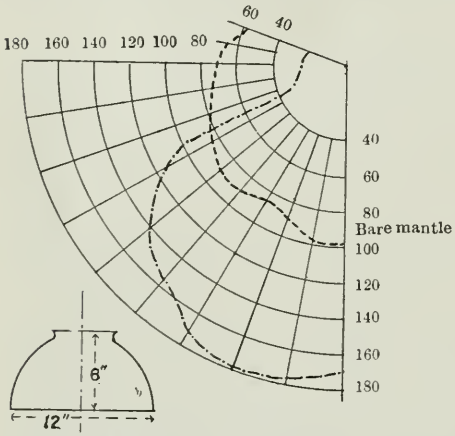


FIG. 6.—Distribution curve of incandescent mantle and mantle in white opal glass.

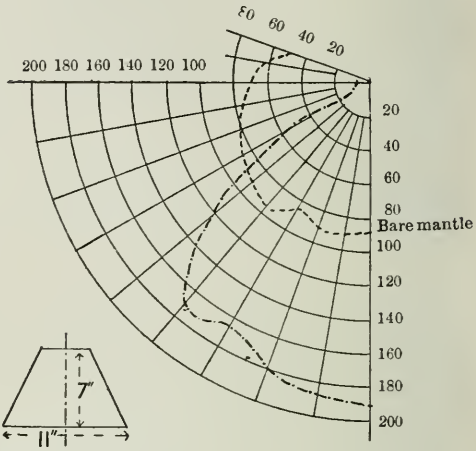


FIG. 7.—Distribution curve of incandescent mantle and mantle in green cased opal glass shade.

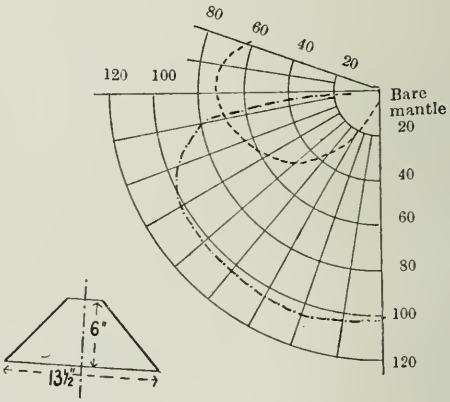


FIG. 8.—Distribution curve of incandescent mantle and mantle in cardboard shade.

Figs. 3 and 4 show two types which are frequently used for industrial work. The material is of white enamelled steel, and the source is a cluster of inverted incandescent gas mantles. Such reflectors serve very well for the general lighting of workshops and other places where a good general

illumination is necessary. They may be obtained in various sizes, so that varying conditions may be met, such as permissible height and spacing, and degree of illumination required.

Fig. 3 is probably more generally suitable than Fig. 4, but for certain special conditions the greater covering power of the unit shown in Fig. 4 is a great advantage.

Fig. 5 is a well-known type of reflector. It is described in the trade as the "parabolic" type, but it is really a segment of a sphere. It is simple, and for the outside illumination of shop windows it serves very well indeed. The "dressing" of a shop window often precludes the use of interior lighting, and it is in such cases that the "parabolic" reflector finds its use. It provides a good illumination on the goods displayed in the window, and protects the passers-by from the glare. The source alluded to in Fig. 5 is a cluster of upright incandescent mantles.

Fig. 6 is a type of reflector frequently used with incandescent gas units, and, if properly installed, will give very good practical results. It consists of an opal dome, so arranged as to cover the direct rays of the source to an angle of 25 degs. below the horizontal. The effect is to considerably increase the flux in the lower hemisphere, and to provide a visible source in the form of the illuminated opal hemisphere having a very moderate surface brightness. Inverted gas mantles are used in the particular unit illustrated. The opal dome reflector is, we think, frequently arranged too high above the light source, much of the useful effect being thereby lost, and the flux in the lower hemisphere being only slightly increased. This, in conjunction with the glare effect due to the insufficient covering of the bare source, renders the unit very much less efficient than when properly arranged.

The necessity for sufficient covering power is frequently overlooked in the application of reflectors, although the hygienic and economic advantages resulting therefrom are fairly obvious.

Fig. 7 illustrates a useful and frequently adopted fitting. It consists of

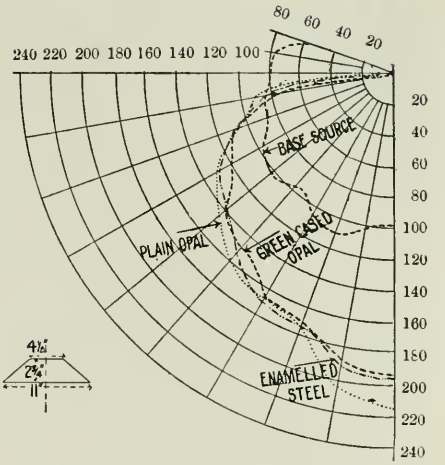


FIG. 9.—Distribution curve of bare source and same in green cased opal, plain opal, and enamelled steel shades.

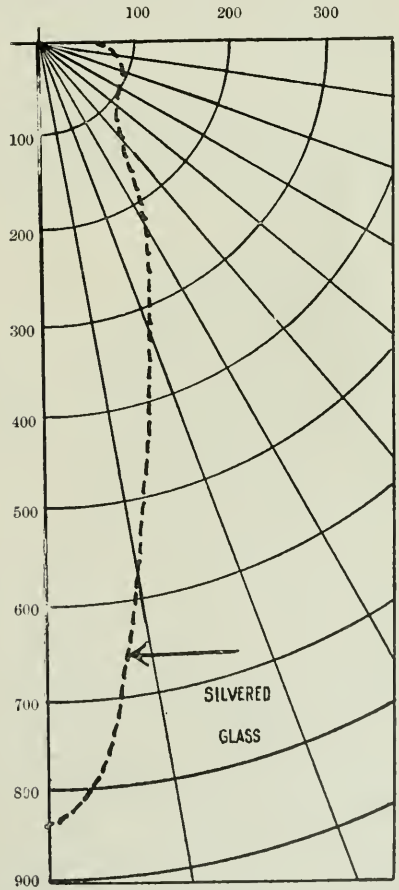


FIG. 10.—Distribution curve of incandescent mantle and mantle in silvered glass shade. [Same source as in Fig. 9.]

a green-cased opal reflector of rather deep conical form, arranged over an inverted gas mantle. Its covering power extends to about 35 degs. below the horizontal, thus forming a local lighting unit. It is used successfully for local lighting in banks and other offices, being usually arranged on the book-racks above the desks. It is the practice of the clerks to throw the heavy books on the racks, thus causing a serious shock to the fitting. No damage is done, however, owing to the use of a simple anti-vibrating device which completely protects the fitting.

The green casing, although only slightly transparent is, we think, more pleasant for office work than a totally opaque material.

We may, at this stage, consider the relative effects of some typical reflecting materials. Figs. 9 and 10 are interesting as bearing on this point.

Four conical reflectors of identical size and contour were prepared for use with an inverted incandescent gas burner, the major diameter being 11 in., and the depth $2\frac{3}{4}$ in. The materials used were :—

(1) Plain white opal.
(2) Green-cased opal.
(3) Enamelled steel.
(4) Silver mirrored glass.

The redistributing effects of these reflectors is shown as a series of polar curves, the same source being used in each case. The curve for the silvered glass is shown separately in Fig. 10, owing to the high flux of light as compared with the other reflectors.

It is interesting to note that in the case of the plain and green-cased opal and enamelled steel, where there is only a small amount of specular reflection, the redistributing effects are so nearly alike as to be regarded as identical. A quite different effect, however, is produced by the silvered glass. The superior reflecting power of this material acts both quantitatively and directionally.

We may infer from these results that, with materials having a minimum amount of specular reflecting power, reflectors of the same form will have approximately the same redistributing effect, and that the quantitative effect will be proportional to the co-efficient of reflection of the surface. Where specular reflection prevails, the redistributing effect may be examined by the application of simple optical principles.

Silvered-glass and prismatic glass reflectors are frequently used for the illumination of hermetically sealed windows, such as are frequently used in confectioners' shops. The units, either electric or gas, are arranged above the glass roof of the window, and out of the line of vision of a person looking in. A practically vertical shower of light falls upon the articles displayed, and, with suitable spacing of the units, a uniform illumination can be obtained.

Fig. 8 shows the result obtained by a common card shade, used in conjunction with an upright incandescent gas mantle. This combination is extensively used for the illumination of billiard tables. The large area of the reflector tones down the shadows produced by the balls upon the table, and the effect may, for all practical purposes, be regarded as shadowless. (Shadows are referred to in another part of this paper.)

Fig. 11 shows a form of diffusing globe, the material being plain opal. It will be seen that the flux in the lower hemisphere is practically uniform, due to the multiple cross reflection inside the globe. This may be regarded as typical of a large number of lighting units.

Fig. 12 shows the redistributing effects of the Holophane prismatic reflecting shades, as applied to inverted incandescent gas. The three standard I., E., and F. types are shown.

Turning to the electric series we find that most of the above comments also apply. Figs. 12a and 13 represent an enamelled iron and ordinary opal shade respectively, the contour being very similar in the two cases. It is interesting to see how closely the two curves agree, the curious peak underneath the lamp being characteristic of shallow polished reflectors of this kind. A shallow reflector such as this, which intercepts only a small portion

of the light, has little influence on the distribution curve. It has also the further drawback that an ordinary metallic filament lamp would be most incompletely screened from the eye.

Figs. 14 and 15 show that shades whose properties are based on the diffusing action of minute suspended

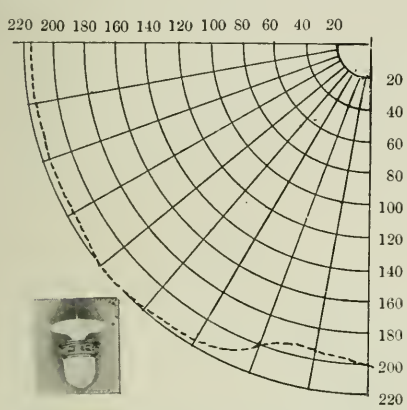


FIG. 11.—Distribution curve of incandescent mantle and mantle in diffusing globe.

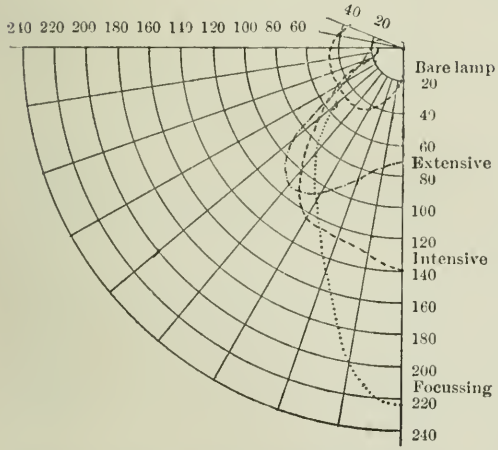


FIG. 12.—Distribution curve of incandescent mantle and same mantle with various Holophane reflectors.

particles (*e.g.*, frosted and opal glass) on transmitted light have in general little *directive* effect. Dense globes of this type tend to give a more or less spherical polar curve, flattening out irregularities. Such concentrating power as is met with in reflectors of these materials is due largely to direct reflection off the shiny "first surface."

Fig. 18 is very interesting as showing the gradual transition in diffusing power as one passes from clear glass to opal. Taking the point immediately below the source we see that the smallest

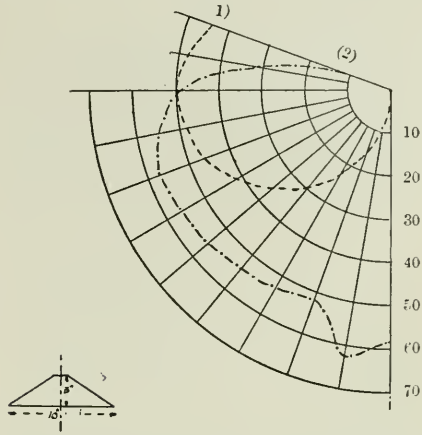


FIG. 12A.—Distribution curve of bare tungsten lamp (1) and same lamp in enamelled iron reflector (2).

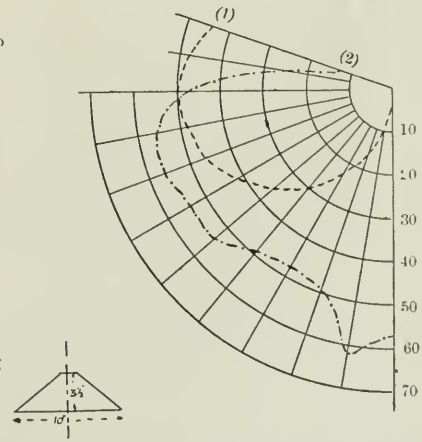


FIG. 13.—Distribution curve of bare tungsten lamp (1) and same lamp in opal glass reflector (2).

candle-power is obtained from the bare lamp; satin-finished glass increases the candle-power slightly in this direction, sand-blasted glass rather more, and opal glass most of all. These three materials, in fact, show an increasing effect on the distribution curve in the above order—a sequence which can be

confirmed by other interesting experiments.

The last illustration, Fig. 20, again shows the results obtained from a deep conical shade of given contour with various materials. Incomparably the most pronounced focussing effect is obtained by mirrored glass, in which direct as opposed to "scattered" reflection is the most important element. Compare with Figs. 9 and 10.

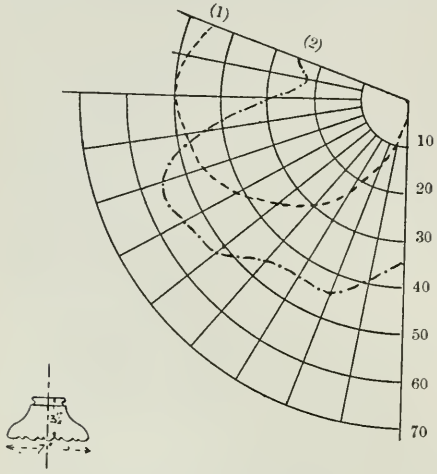


FIG. 14.—Distribution curve of bare tungsten lamp (1) and same lamp in white glass reflector (2) (open type).

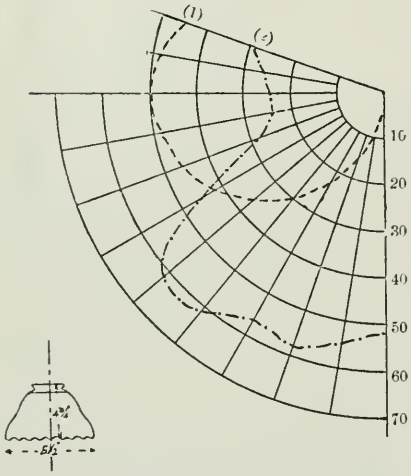


FIG. 15.—Distribution curve of bare tungsten lamp (1) and same lamp in white glass reflector (2) (bowl type).

Value of Exact Data on Shades and Reflectors.

The foregoing examples should serve to show what marked differences in the distribution of light may be caused by slight modifications in the form and material of shades and reflectors. It is becoming increasingly common for manufacturers to give the polar curves of light distribution resulting from a given source with a specified shade or reflector, and information of this kind undoubtedly adds considerably to the value of such a unit.

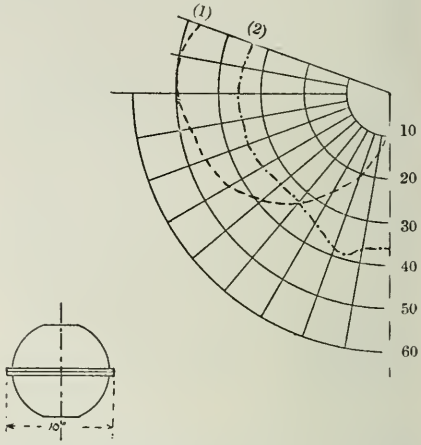


FIG. 16.—Distribution curve of bare tungsten lamp (1) and same lamp in white glass globe (2).

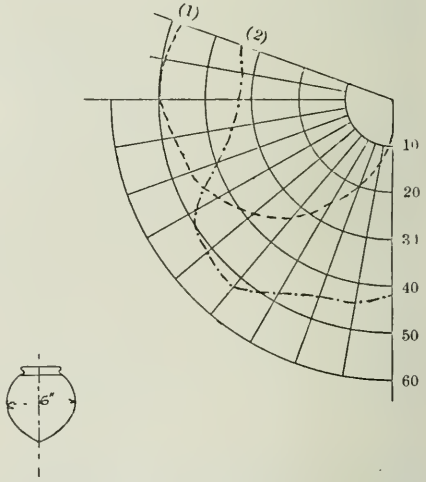


FIG. 17.—Distribution curve of bare tungsten lamp (1) and same lamp in Holophane globe (2).

When one has no knowledge of the effect of a given type of shade it is impossible to form an accurate idea as to what the illumination will be. Yet, if we may judge from the events of the last few years (as exemplified in the series of photometric measurements recently made on behalf of the Home Office by Mr. D. R. Wilson), the tendency in the future will be to specify the actual illumination on the working plane, and the contractor will have to know how to place his lamps in order to secure that illumination.

When the polar curve of a unit is given, a person with some knowledge of illuminating engineering can readily work out the resulting illumination when the lamp is placed at a given height, and determine how the lamps should be spaced in order that the illumination over the room may be approximately uniform. Some manufacturers supply diagrams enabling the illumination to be calculated, and state spacing rules for a given type of reflector. When even illumination over a considerable area is demanded such data are very useful.

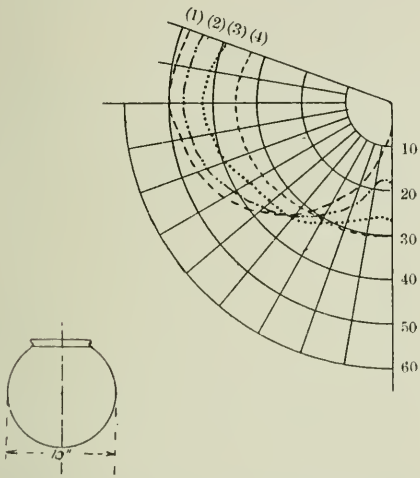


FIG. 18.—Distribution from (1) bare lamp, and same lamp in (2) acid etched (3) sand-blasted (4) opal globes respectively.

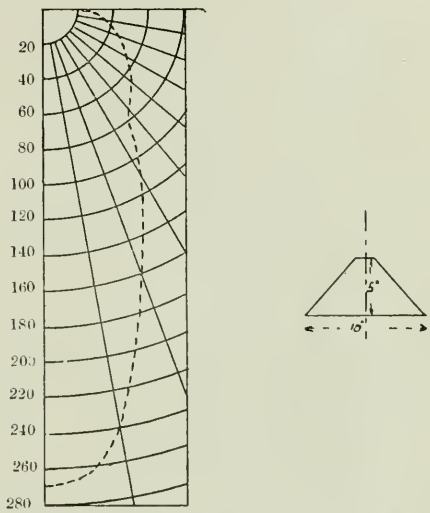


FIG. 19.—Distribution curve of tungsten lamp in fluted mirror glass shade.
[Same source as in Fig. 18.]

Diffusion of Light and Shadow-Effects.

We have already mentioned the production of shadows as an important point in the art of shading, and with this in view it may not be out of place to consider one or two aspects of this question.

The sharpness or definition of a shadow does not depend altogether on its actual density. The gradient of the density of the shadow at the edges has a marked effect on its visibility, and is an important factor from the practical standpoint. This gradient of density in turn depends upon the intrinsic brilliancy and area of the light source, a source having a large area producing much less intense shadows than one having a less extended surface.

When a light source is equipped with a reflector the reflector becomes part of the source, and for practical purposes the two must be considered together as one unit.

In the case of diffusing reflectors, as, for instance, Holophane, opal, white glass, enamelled steel, &c., the extension of the area of the light source that accompanies their use tones down the edges of the shadows so that they become much less visible than when no reflector is used.

Shadow density may be defined in terms of the percentage drop in illumination between two adjacent surfaces. Thus one may take (1) a

reading of the illumination on the brighter portion, and (2) a corresponding reading for the darker portion, and then subtract (2) from (1), and express as a percentage ratio with regard to (1).

(It has been suggested that, in practice, the value of this percentage should preferably not exceed 20 per cent, otherwise the depth of the shadows may be inconvenient.)

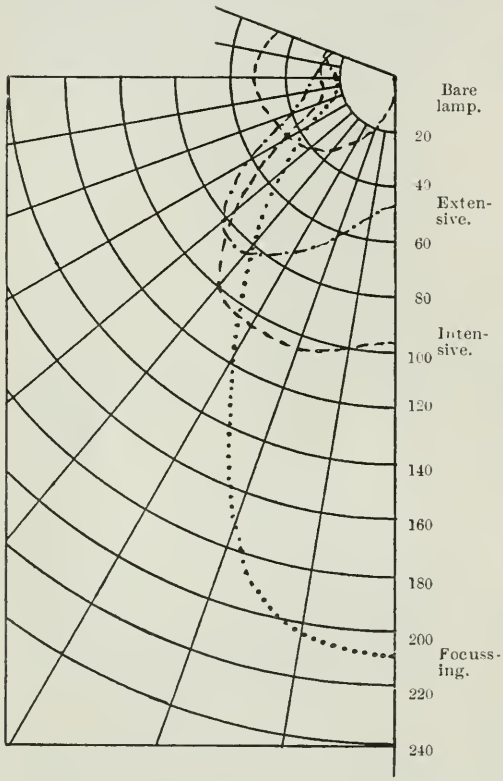


FIG. 20.—Distribution curve of bare lamp and same lamp with various Holophane reflectors.

Figs. 21 and 22 are interesting as illustrating in a practical way the effect of an extension of the area of the light source in subduing shadows. A lamp was arranged 8 ft. above the ground and near a stanchion, so that a shadow of the latter was cast upon the ground—a condition of things that often obtains in factories and workshops.

The illumination was explored transversely across the shadow, a photometer being suitably arranged for this purpose. The shadow was explored under four conditions, namely, with one, two, and three mantles alight, and with the three mantles plus the reflector, a simple slightly concave enamelled steel reflector being used for this purpose.

The results form a series of cascades, each step representing the shadow produced by one of the mantles.

Fig. 22 has been plotted from the same data, the illumination at the various points being expressed as a ratio, the value at the centre of the shadow being taken as unity. The gradient of the steps, therefore, represents the sharpness or definition of the shadow.

The diagrams show very clearly the advantages of extending the area of the light source. The curves in Fig. 22 tend to straighten out as the source is extended, until, under the conditions specified for curve No. 4, it becomes almost a straight line.

A straight line would, of course indicate a practically invisible shadow.

As a means of avoiding harsh and abrupt shadows one may also take advantage of reflection from walls and ceilings. Inconvenient shadows are much more apt to be produced in very dark rooms than when the surroundings are fairly light in tint. In fact, the most extreme instance of the principle of distributed sources of light is indirect lighting, when the light is thrown upwards on the ceiling.

Indirect lighting has been so recently the subject of a special paper before the Society that one hesitates to say much more on this point. But it occurred to us that a brief account of some preliminary experiments carried out by one of the authors might be of interest. Very little numerical work has yet been done on shadow-production, and some standard method of comparing the qualities of different systems of lighting in this respect seems needed. The most obvious method of investigation seems to be to

take some standard object, of specified size and mounted an agreed distance above a white surface, situated in the working plane. Illumination readings of the shadow-contrast might then be taken and supplemented by photographs (naturally taken entirely by the light of the systems to be compared). At the present moment it is not proposed to give any detailed numerical results, but in order to illustrate the method we have reproduced in Figs. 23 and 24 two photographs taken respectively by direct and indirect lighting. On the table will be seen the shadow-tester, consisting of a small sphere and a disc at the end of a rod. Information can be gained from the appearance of the sphere itself, as well as the shadow cast by it.

In Figs. 25 and 26 we have an enlarged view of the shadow-tester. Only one central light (respectively direct and indirect) was used in each case. The illustration shows very clearly the difference in the sharpness of the shadows.

In considering the ideal shadow-conditions to be aimed at most people would probably suggest that one ought to imitate daylight, to which indirect lighting has frequently been compared. On broad lines the majority might agree that daylight has not been excelled by any system of artificial light. Yet it will be observed that the nature of daylight itself varies quite noticeably according to climatic conditions. Daylight can, therefore, be studied to some advantage, and it is worth noting the similarity between various kinds of daylight and the different methods of artificial lighting adopted in practice.

For instance, on a bright day the direct light from the sun is about 80 per cent of the total, only 20 per cent being diffused by the blue sky. This is analogous to a direct tungsten or inverted mantle source equipped with a prismatic reflecting shade, placed reasonably high up. When the sun is almost hidden behind clouds it is quite possible for the conditions to be such that 20 per cent only of the total light is direct, the balance of 80 per cent being diffused, thereby producing semi-indirect lighting conditions. Again, if the sun is entirely screened by clouds, we have conditions almost analogous to artificial indirect lighting.

We think that it is easy to over-rate the supposed comfort produced by total indirect or diffused lighting. Providing the sun is not shining directly in one's eyes, a bright, sunny day with a rich blue sky is really less glaring

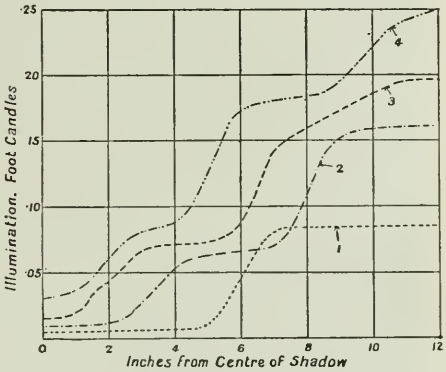


FIG. 21.—Distribution of illumination below one, two, three and four mantles.

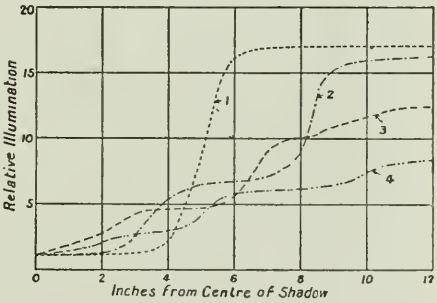


FIG. 22.—Same curves reduced to common value at zero.

No. 1 curve		one mantle.
No. 2	„	two mantles.
No. 3	„	three mantles.
No. 4	„	three mantles (with reflector).

than a bright, cloudy day, for the reason that in the case of the latter the luminous area is so great that one cannot gain any protection.

The difficulty with artificial lighting in practice is to reproduce the best direct daylight conditions with the means at our disposal. Artificial direct systems should, in order to compare favourably with direct daylight, comply

approximately with the following conditions :—

(*a*) Give relief from glare for all normal positions of the eyes.

(*e*) Produce single shadows, or one intense shadow surrounded by very soft ones. Intense shadows should always be thrown in a harmless direction.

FIG. 23.—Showing shadow-tester illuminated by direct light.

(*b*) Distribute over the lower hemisphere 80 per cent of the light.

(*c*) Diffuse into the upper hemisphere 20 per cent of the light.

(*d*) Give fairly uniform illumination over the working planes.

(*f*) Give a horizontal illumination, and surface brightness in excess of the average value for the walls and other upright surroundings.

(*g*) Give as far as possible an equivalent colour-value.

These are important points to bear in mind in connexion with all kinds of shades, as their influence on the intensity of shadows, &c., can be very great. One crucial difficulty that direct lighting systems (other than local point lighting) meet with is the arrangement of the furniture, and, in the case of workshops and factories, columns and stanchions. These are, as a rule, arranged to suit daylight conditions. Low ceilings are another difficulty.

It will be conceded that, as matters stand, indirect, semi-indirect, and well-shaded local lighting, with a low value of general lighting, are all methods which have undoubted advantages in certain circumstances.

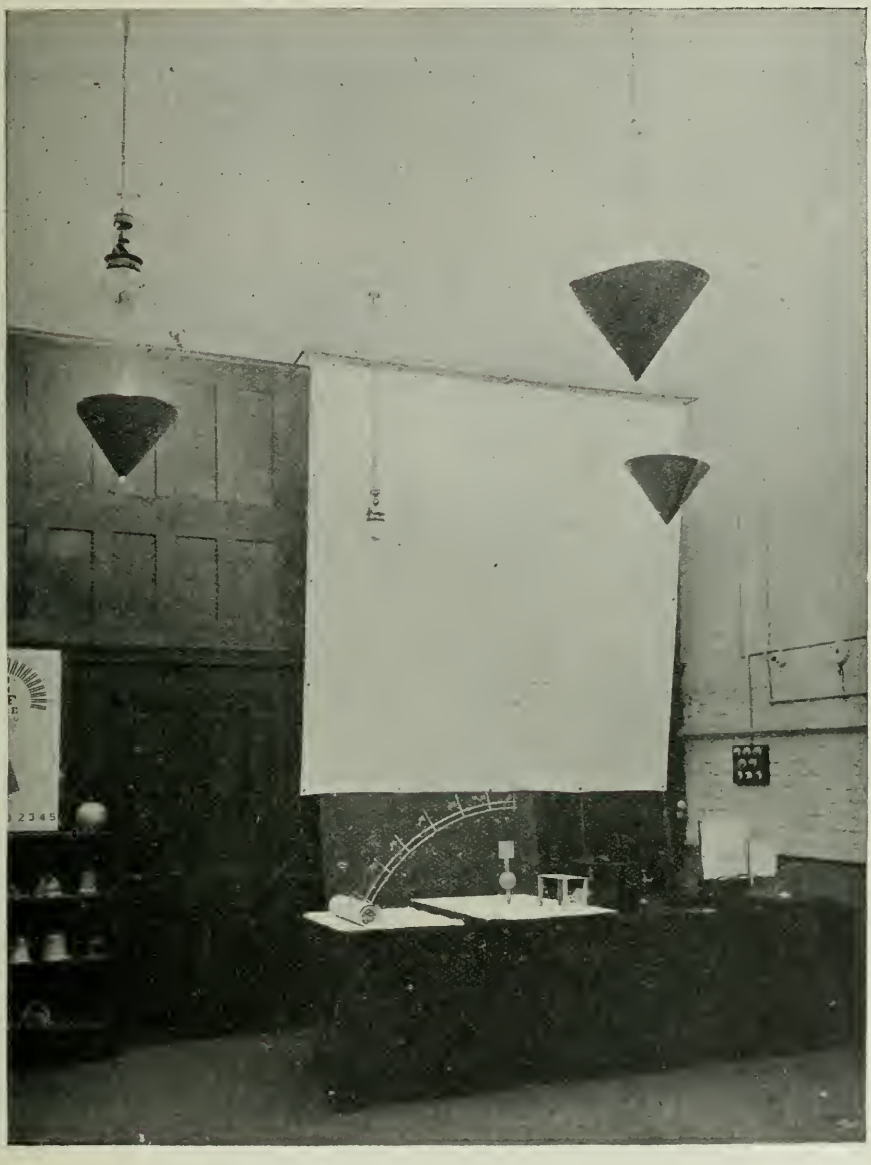


FIG. 24.—Showing shadow-tester illuminated by indirect illumination.

It is well to realize that the use of a number of extended direct sources, covering a considerable area, does materially diminish the sharpness of shadows and the possibility of glare from shiny surfaces. The suppression of these defects is not solely an attribute of indirect lighting; in fact, there is more scope for the improvement of direct methods of lighting, with a view to producing soft shadows, than some recent expressions of opinion in this room might suggest.

It is a frequent misconception to think that cloudy daylight or indirect artificial lighting is perfectly "diffused" and shadowless lighting. An

FIG. 25.—Larger view of shadows cast by single direct unit in centre of room

FIG. 26.—Larger view of shadows cast by single indirect unit in centre of room.

object is usually illuminated partly by direct light from the sky and partly by reflected light from the walls and ground, sometimes receiving the major portion of its illumination from the sky, and sometimes *vice versa*, this varying proportion causing the gradients of light and shade which give perspective to the object. If no such gradient of light and shade existed, we should have no visual conception of a third dimension, and architecture would have no existence.

The question may be raised, What is meant by "diffused" lighting? Some use this term in connexion with the brightness of shades, and say that good diffusion is produced when all parts of the shade appear equally bright, and the intrinsic brilliancy does not exceed a certain value per unit area. On the other hand, Luckiesh says:—

> "The uniformity of the distribution of illumination about a point is useful as a measure of the degree of diffusion of light at that point."

It is, therefore, evident that "shade diffusion" and "illumination diffusion" should be distinguished from one another, and should both receive consideration.

One would conceive that perfect illumination diffusion, in the sense of the definition given, is only obtainable inside an Ulbricht sphere, and it is worth bearing in mind that, even in this case, an irregular matt white object would not appear uniformly bright; in other words, the object would have both depth and perspective. With cloudy daylight or indirect artificial lighting it is, at most, only the upper hemisphere which acts as the source; consequently, real shadowless lighting is fortunately unknown in practice. We say fortunately, because such a state of things would be unbearable. It would give us no visual conception of a third dimension.

With this comment we may bring the paper to a close. As explained at its commencement, it has been found necessary to omit entirely certain sections of the subject. The use of shades and reflectors in connexion with high-power lighting (electric arc lamps, high-pressure gas, &c.) has not been touched upon, although it is fully realized that the need for improved methods of shading is quite as great in this section as in the case of low-power lighting. Much of what has been said will, however, be found to apply to both branches of illumination.

It has been the aim of the authors to proceed on broad general lines, and most of the diagrams have been selected to illustrate some fundamental principle. We have also thought fit not to include photographs of installations within the body of the paper, but several will be found in the Appendix. These have been selected merely because

they seem to illustrate aptly some of the points referred to in the paper, as well as being somewhat exceptional installations likely to interest members of the Society.

APPENDIX I.

Although not directly connected with the subject of the paper, the two photographs appended herewith might prove useful as illustrating two interesting aspects of artificial illumination.

Fig. 1 shows an installation of high-pressure incandescent gas for the illumination of the covered tennis courts at Dulwich. The lighting as now arranged is regarded by the players as highly satisfactory, but a considerable amount of experimental work was necessary before the final conditions were arrived at. Naturally the players judge the lighting upon preconceived standards founded on their daylight experiences, and this no doubt accounts for the necessity for the preliminary experimental work that was carried out. However, the results now obtained will be of great value in planning future installations of a similar character.

Each court is illuminated by ten Keith high-pressure 1500 c.-p. inverted gas lamps, one over each of the serving lines and four along each side of the court.

The lamps over the serving lines are of a focussing type, mirrored glass being used, and the shades are sufficiently deep to completely obscure the source, excepting, of course, near the vertical line.

The special feature, however, is the general illumination of the court, and for this purpose the lamps along each side are equipped with a special type of reflector, the character of which may be seen from the photograph. It is of equilateral triangular form. In the case of the lamps nearest the net the square opening in the reflector is unobscured, but the lamps nearer the serving line are partially obscured by opal glass, to prevent direct rays from the mantle reaching the eyes of the players.

One of the advantages of the present system of lighting is that the flight of the ball can be watched in all positions without any appreciable glare effect from the lamps, while at the same time the illumination is adequate and uniform, being about 3½ foot-candles within the playing area of the court.

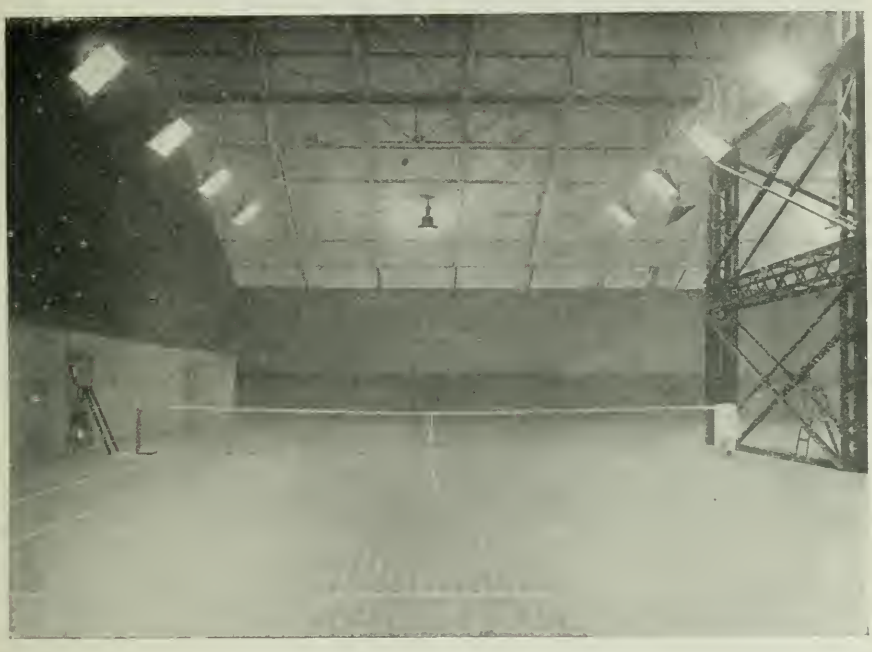


Fig. 1.—View of high pressure gas lighting installation at Dulwich covered lawn tennis courts showing special methods of shading.

The great diffusion of the light in the present installation reduces to a minimum the shine effect of the floor. The boards naturally get very smooth by the friction of the players' shoes, and the shine would probably be a disadvantage with a less diffusing method of illumination.

The installation is interesting as showing how the requirements of a particular problem may be met by the use of special reflecting shades. These shades were designed by the staff of the South Metropolitan Gas Company.

The second photograph shows an installation of low-pressure upright incandescent gas lighting in a church—St. Mary's, Stoke Newington. The structure is a very beautiful one, and is designed on the lines of Salisbury Cathedral. The installation is of a simple character, slightly opalescent shades being used, and the fixtures arranged along the centre of the aisle.

It would seem that the utmost simplicity is desirable in arranging the lighting of a church.

FIG. 2.—Showing lighting of St. Mary's Church, Stoke Newington : simple opalescent shades are used.

The light in this case is well diffused, and brings out the features of the structure very well indeed.

The illumination on a plane corresponding with the reading position of a book is about $1\frac{1}{2}$ foot-candles, and this appears to be quite sufficient for the purpose.

APPENDIX II.

The illustration shown in Fig. 1 has been reproduced as showing the advantages and drawbacks of shades of the ordinary silk pattern. The general effect in this case might well be considered pleasing and decorative, and the metal filament lamps are completely screened from the eye by the conical shades. On the other hand, the fact that the maximum candle-power from the filaments (emitted horizontally) occurs at just the place where the silk is interposed must lead to a considerable loss of light. In this case efficiency is not very important, but the illumination (only $\frac{3}{4}$ft. candles), is on the low side, and might have been

FIG. 1.—Illumination of a drawing-room with silk shades.
(Note bright patches of light on the ceiling above shades.)

considerably increased had some form of shade with good directive power been used. It is sometimes a good plan in such cases to use translucent reflectors under the silk shade; these concentrate sufficient light downwards, but transmit enough to illuminate the silk surface.

Another result of the use of shades of this type, which absorb a great deal of light, is that the ceiling is unevenly illuminated. Above each shade will be observed a bright ring on the ceiling. Had the shades been entirely opaque this effect would have been still more marked. When opaque shades are used for general lighting care is often needed to avoid an abrupt transition from brightness to shadow round the walls of the room.

Fig. 2, a photograph of the Moore light installation at Liverpool Street Station, is included merely as an illustration of a somewhat novel and a highly diffused method of lighting giving soft shadows, and having a low intrinsic brilliancy which is considered to require no shading. On the other hand one can imagine that a suitable reflector fitted above the tube, and throwing much of the light downwards, would also be advantageous in some cases. The question of shades and reflectors for tubular sources of light is an interesting one that has not been considered to any great extent as yet; there would appear to be considerable possibilities for such appliances in connexion with the lighting of extensive vertical surfaces. The "Uniflux" reflector designed by one of the authors in conjunction with Mr. S. D. Chalmers* is an example of this type of reflector. Although apparently simple in construction, it affords a somewhat complicated problem in direct reflection, the solution of which demanded higher mathematics.

Fig. 2.—View of new Moore lighting installation at the Central London Railway, Liverpool Street Station.

* See *Illum. Eng.*, Lond., vol. iv., 1911, p. 145.

Discussion.

The Chairman expressed his interest in the variety of points touched on in this paper. The suggestion that there should be a discussion on bad examples of lighting was a good one, and no doubt the Council would consider such a discussion. But was it not probable that it would resolve itself into a discussion on shades and reflectors or their absence? It was usually the misplacing or absence of shades and reflectors that led to bad lighting. This led to the question of damage to eyesight, which was one of the most important with which the Society could deal. It was astonishing nowadays to see the large proportion of young children and grown-up people who wore spectacles.

The indifference of the average user to the cleanliness of his lamps and shades was also quite remarkable. It was no use putting lamps in good positions if they were left there untended until the light became so extremely bad that nobody would stand it any longer.

The suggestion that makers should give polar curves with all their lamps in future was one which would be cordially welcomed, and they would be all the more valuable if these curves were prepared by some independent testing laboratory, as there was always a temptation to makers to exaggerate even polar curves. It was very necessary that something better than the very vague definitions of candle-power now used by makers should be given.

He agreed with the authors that the value of indirect lighting, as compared with direct lighting, was frequently over-estimated. Another point was that reflection off walls and ceilings might tend to colour the light, and it would be rather interesting if some experiments could be carried out as to the effect upon the possibilities of colour discrimination with indirect lighting, as distinct from direct lighting, using the same illuminant. Was there any difference in the power to discriminate colours with one system as compared with the other?

Mr. John Darch said he wished to thank Messrs. Clark and Mackinney for their excellent paper on the use of shades and reflectors. It had both pleased and disappointed him. It had pleased him because it contained so many good thoughts and such a useful series of painstaking tests of the effects of the market types of shades to enrich the *Journal* as a reference book, but had disappointed him because, in his opinion, the real duties of a shade did not appear to be sufficiently appreciated.

The elementary fact in shading was that the eye could not stand a brilliant light. Was it not a fact that one of our most constant occupations, conscious and unconscious, was that of dodging the stings of exposed lights? The counter-fact was that light is healthy and desirable. Did we not naturally gravitate to the lighter end of a room?

Light is both good and bad for us. The fire that burns our fingers to-day is the same fire that cheered us yesterday, and will cheer us again to-morrow. The beneficial use of these things needed but a little common-sense. We wanted a shade that would, at the same time, protect us from the dangerous intensity of a light source, and yet permit the distribution of its beneficent rays. A shade that unnecessarily blocked light was wasteful and unhealthy. And yet, what did we find in the houses of our friends, and stacked up in thousands in the shade-makers' warehouses? Glass shades that for the most part were misnomers! He was referring to shades, not reflectors. The transparent kinds were useless, for they did nothing, while they were doubtful ornaments. The translucent kinds, such as opal, the double-frosted, and the prismatic glass did modify the light, but in most cases they left too bright a spot before the eyes. The intrinsic brilliancy of the shade surface should not exceed one-tenth of a candle-power per square inch. This, of course, is dependent upon the brightness of the background, for contrast is a physiological problem, and Prof.

Weber deprecates a stronger contrast than 1 in 100. Bare lights or brilliantly illuminated shades would bring the contrasts to an enormously higher figure than this. The ideal was that a shade should not be brighter than the background, and this may be attained by the use of semi-opaque shades of dense glass, earthenware, silk, &c.

Several references had been made to the decorative purposes of shades. There is a prevailing impression that utility means ugliness and ornament means usefulness. Unfortunately, we frequently concede the application of fittings and accessories that are useless for the sake of ornament, and in doing this we put art in a false position. Beauty in a thing is a convention arising out of its adaptability to a purpose. The unconventional is always deemed ugly at first and beautiful later. If we aim at simple utility, art will soon enough enthrone its forms.

The authors' introduction to their paper, Mr. Darch added, was a capital survey of the situation. But he would like to draw attention to another remark in the second definition (page 129). The definition itself was all that could be desired, but the parenthetical explanation, in which it is stated that the light should be so directed as to reduce the illumination on the upper part of the room (again referred to near the end of the paper as 20 per cent on the upper half, and 80 per cent on the lower half), had better, he thought, either been omitted or further explained. He mentioned this, as he knew that the authors had advocated the same view elsewhere. They assumed that all rooms are to be considered as having a working plane, as though they were offices, schools, or workshops. This is all very well where the usual working plane is an actual or virtual necessity, but it is a mistake to apply this principle to every room, for concert-rooms, ball-rooms, drawing-rooms, and many others are best illuminated in such a way that the ceiling and upper walls are at least as highly illuminated as the lower parts. Diffusion is thereby better: objects appear more natural, and the general good effect is enhanced. It was only on the previous evening, Mr. Darch continued, that he went to the Æolian Hall, Bond Street, for the first time since the alteration in the lighting, and was delighted with the charming effect produced by the stronger and special illumination of the ceiling, although there are many points in it that might be improved upon in point of economy in lighting. During the course of his remarks, Mr. Darch demonstrated on the screen a method of shading which would meet the points raised in the early part of his remarks. The diagram showed a section of a room with bracket lighting, shaded by small semicircular silk shades in front of the light source. He pointed out that in standing or sitting one's eyes were no higher than 5 ft. 6 in. or lower than 3 ft. 6 in. Consequently, the perambulation of the eye was within the central shaded space, and it was unnecessary to shade any more than that portion. The result was that a person could sit immediately under the lamps and read with the full illumination on the book, whilst the walls and ceilings were also well illuminated without any glare effects.

The expression "white glass" used in connexion with Figs. 14, 15, and 16 should be more precisely defined, as the context does not make it clear whether clear glass, frosted glass, or opal be intended, and there is an important difference in their behaviour.

Not the least useful part of the paper was the explanation given of the zonal emission of light at various angles. The statement is made that if the c.-p. of a source is the same at all angles, the photometric value of the light is greater within the lower angles than the higher—as much as $2\frac{1}{3}$ times is stated. This is not so in fact. He thought it should be made clear that the difference is simply the difference of the area of the various zones. The light from a similar solid angle must be the same whatever the direction it takes, and the same remarks made by the authors would be equally applicable were the equator vertical and the poles horizontal.

In conclusion, Mr. Darch said that, although he had found something

to criticize, he appreciated the pains that had been taken, and he was sure the paper would be greatly appreciated by all readers of the *Journal* as well as those present.

Mr. Arthur Blok welcomed the paper as dealing with a subject in which there is great need of information, not only among those concerned in installing light, but also among those using it. He supported strongly the Chairman's view that manufacturers of fittings might do a great deal more towards supplying polar intensity curves indicating the performance of their wares: the polar curve should be as important an integer in trade literature as photographs of the shades and reflectors to which they belong, and he looked forward to the time when manufacturers and vendors would freely follow the example of those who had already begun in this direction. At present we have the anomaly of a consumer protesting strongly at an increase of a penny per thousand feet of gas—a matter, perhaps, of 3 per cent on his bill—while he is quite unable to ascertain whether his globes waste 3, 10, or 30 per cent of the light for which he pays.

He appreciated the very great amount of work which must have been entailed by the authors in getting together the collection of curves shown in the paper, but he felt that the paper might be still improved by the addition of further numerical data. With Mr. Mackinney's careful methods, there must be behind those curves a vast supply of valuable data, such as mean spherical and hemispherical values, absorption coefficients, &c., and he hoped that some of this was not put on record.

He deprecated the use of the single term "shade" for all devices, in view of the available terms "globe," "shade," and "reflector." There seemed room for more accurate definition here: thus "reflector" might be limited to a device which redistributes light by reflection, "screen," or "shade" to one which reduces light by direct interposition, and "globe" to one which redistributes by transmission. Although these three functions obviously may overlap in a given device, they might afford the working basis for a classification.

He pointed out the all-round need for more data regarding "fancy" shades, &c.—*i.e.*, those having an element of ornament as distinct from strictly utilitarian designs. These probably constitute the majority of the devices sold at the present time, but the difficulty of any organized testing of such varied and numerous products seems to have stood in the way of their investigation. There is, without doubt, ample need and room for systematized work in this connexion. He asked the authors to describe the method employed in deriving the curves shown in the paper; his own method was the use of a form of three-mirror rotator, which

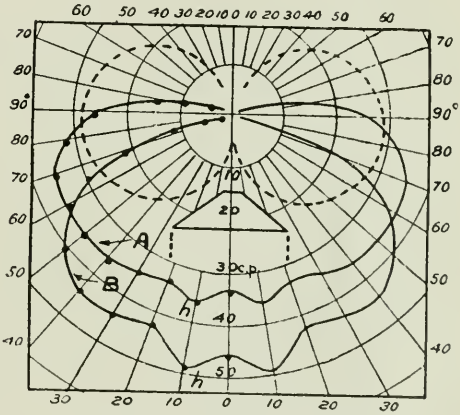


Fig. 1.

gave very good results. The preparation of such curves by makers or others clearly must rest upon the availability of suitable and reliable apparatus. The thing must be got beyond the laboratory stage.

The humps referred to by the authors on the curves in Figs. 12A and 13 were evidently due to specular action, and the effect may be observed easily by walking under any glazed cone while looking up into it. In the appended curves (Fig. 1) the effect is shown at *h*, the curves A and B being the distribution given by a card cone with and without the addition of a three-inch petticoat, used with a metal filament lamp which gives the dotted

polar curve when bare. In testing a certain 9 in. by 3 in. opal cone, he had found the candle-power increase suddenly from 23 to 47 within an angle of only 5 degrees, giving an extremely sharp local projection on the curve. When the inside of this cone was etched with hydrofluoric acid, however, the projection vanished, thus showing its specular origin. Reflectors with this characteristic obviously tend to give a "spotty" ground-illumination. He exemplified the importance of correct centring of prismatic reflectors with regard to the light by some curves showing the effect of raising a focussing and an intensive reflector through ¾ in. with regard to the lamp. In the former case, the whole focussing effect was lost, and he had, moreover, found indica-

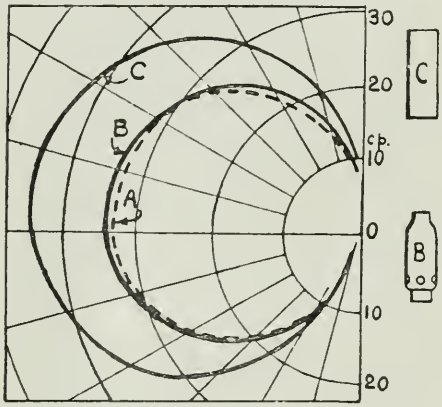


Fig. 2.

tions of an actual loss of light. Could the authors endorse this loss? He pointed out that the ordinarily accepted absorption values for clear glass must be applied with caution to globes used with flame sources. An upright gas mantle (Fig. 2) gave, when bare, the dotted curve A, but when a clear cylindrical chimney was added the curve became inflated, as shown at C. By a separate test this chimney was found to absorb about 4 per cent of the light passing through it, but its effect upon the temperature of the mantle, and possibly also upon the gas mixture, was such as to produce a net increase of 36 per cent in the light flux. This intensive effect is practically absent when a "normal" clear glass chimney with air-holes is employed. The curve B shows the effect of using such a chimney on the same mantle in identical conditions to those obtaining when the plain cylinder was used. The inrush of cold air at the holes appears very approximately to counteract any thermal screening which the upper part of the cylinder may exercise upon the mantle, and the flux is hardly increased at all.

Mr. Frank Bailey referred to the authors' definition of one function of a shade, namely, the screening of the source of light from the eye and the avoidance of glare, and remarked that very few of the shades with which the authors had experimented conformed to this first principle. It was for this reason that he thought there seemed to be some confusion of ideas in the use of the terms "shades" and "reflectors"; because all shades were not reflectors, and all reflectors were not shades. One of the chief difficulties with many shades was that of keeping them clean, as only by this means could the best results be maintained. At present some of the best shades were the most difficult to handle in this respect.

He wished the paper had dealt with the question of bowl lighting, by which he did not mean indirect lighting, but something in the nature of semi-indirect, which was now becoming very common, and which he felt confident would very shortly replace a large number of fittings at present employed. As soon as it was realized that what was wanted was good illumination below the light rather than brilliancy in the sources themselves, bowl lighting would come into very common use indeed. An objection was that the bowls now made were small in size, and were limited to about 14 in. diameter, and when dealing with a large room such a size was useless, because it would need a large number of these bowls looking like balloons hanging all round the room. The difficulty at present in making large bowls of glass was one of weight, and there was great scope for a manufacturer to take up

the question of making such bowls in sections.

Probably glass and porcelain were not the only materials. There was gelatine and compressed tissue-paper, which might very well be worked up, and if this were done, possibly very large and indestructible bowls could be made. We were entirely dependent on the manufacturers of glass, and this was a subject which was receiving little attention in England at present. We seemed to be content to order it in any quantities from Hungary, Germany, and the United States. One would like to see the English glass-makers devoting more attention to the growing demand for ornamental glass of a character that did not absorb too much light. It would be beneficial both to the Society and to the glass-makers if they could get into touch with each other, so that a glass-maker could learn exactly what was required.

Prof. J. T. Morris said it would be most valuable if makers of shades and reflectors would give in their catalogues polar diagrams of the distribution of light brought about by their shades, though this would be a difficult matter owing to the divergence of outline of the various sources of light in use.

Commenting on the general disregard of the principles which should be applied in good lighting, he mentioned three cases which had come under his notice on the way to the meeting: first, in a tramcar, which was illuminated with bare metal filament lamps having no reflectors; second, in a restaurant, where bare metal filament lamps were again used, but with shades of such a nature that he felt certain that they were absorbing at least 40 per cent of the light, without even having the merit of being ornamental; Thirdly, in a train which was illuminated with carbon filament lamps, non-frosted, with shades or reflectors of opal, placed high above the sockets of the lamps, which did nothing but screen a small portion of the ceiling and reflect an exceedingly small part of the light. There was a tremendous amount of work to be done in the way of educating the public, and even the engineering world with regard to the proper use of shades and reflectors.

The common oil lamp used so much in domestic lighting had been mentioned in the paper. Here, again, no serious attempt had been made at scientific shading, and as, in his opinion, the oil lamp still had a future before it, he thought that much useful work could be done if the makers of shades for these lamps took the question seriously in hand.

Mr. H. C. Wheat showed two slides illustrating bowl reflectors, with depolished surfaces, which, he said, illustrated the possibility of producing an efficient reflector of this nature. He welcomed the authors' serious attempt to deal with the definition of shadow-density. A good deal was heard about the intensity of the illumination, but that was only one factor in shading, and the authors' Figs. 25 and 26 showed the enormous advantage, so far as shadow was concerned, to be obtained by indirect over fully-direct lighting. He believed the authors would admit that the greater the amount of light reflected, and the lesser the amount coming direct, the better the shadow effect. This did not seem to bear out the authors' recommendation of fully-direct lighting as against semi-direct lighting.

As regards daylight, he could not suppose the authors seriously suggested that bright sunlight was a suitable working or reading light. At any rate, it was not obtained indoors, and it was indoors that most people had to work. It was generally recognized that the sun behind clouds gave the best indoor light possible. The authors seemed to suggest that it was trying to the eye, but was only so when one looked out of the window at the source of light, and he believed that all who were members of the Society knew that sources of light were not meant to be looked at.

Mr. Haydn T. Harrison remarked that in order to comply with the suggested degree of brilliancy, namely, $2\frac{1}{2}$ c.-p. per square inch, it would

often be necessary to have a globe of considerable area. For example, if the light sources in that room were within a single bowl, as suggested by Mr. Bailey, it would have to be about ten or fifteen feet in diameter, and would have to be made of some other material than glass. But if this were done the illumination would be much more satisfactory.

A point not always realized was that the people who supplied reflectors and shades were not always the makers. They were the people who bought them and insisted upon having them at some such figure as $2\frac{1}{4}d.$ each. Shades could only be obtained at these prices from Germany or Austria, because our own makers would not go in for this rapid reproduction work. It was well known that the best translucent glass was produced in England, but when it was a question of glass only partially translucent, our own glass-makers were not satisfactory because they would not experiment nor put down the necessary machinery unless they were guaranteed a market. The Society was now teaching the public the value of good shades and reflectors. When they had learnt that they could not only save their pockets, but also their eyes by paying a little better price for properly designed shades, then the British glass-makers would have an opportunity of having their fair share of the market if they would take the trouble to make the necessary preparations.

Mr. G. Campbell congratulated the authors on their paper. Naturally there were many points that could not be discussed in the time available, and he hoped that the Council of the Society would consider the possibility of having another paper later on in which these could be dealt with in detail.

The value of correctly designed reflectors could scarcely be too greatly emphasized, but it was important to note that the position of the light source and reflector was also vital. This matter should be brought to the attention of lamp manufacturers, so that the position of the filaments in the lamp bulb could be standardized in the same way as was proposed for the candle-power, and the dimensions of bulbs and caps of lamps. It was also necessary that the gallery carrying the reflector should be of the right dimensions, so that the lamp should be maintained in the correct position for which it was designed.

He thought the suggestion made in the discussion, that one should use large bowls made of glass or other material measuring several feet in diameter, was hardly practicable.

Some remarks had been made as to the desirability of awakening English glass manufacturers to the possibilities of making glass for purposes of illumination. It might be of interest to mention that a large percentage of the prismatic glass reflectors in use were now made in England.

In conclusion, he might add that the point raised by the Chairman as to the colour of light received from indirect systems was one that had come within his experience. He thought that artificial light—whether direct, semi-indirect, or indirect—could not be relied upon to give a true colour-value unless assisted by a suitable colour-screen. It was true that daylight itself varied considerably from one season to another during the year, but such changes were small in comparison with the enormous difference between average daylight and artificial light.

Mr. T. E. Ritchie referred to the authors' suggestion that it was desirable to imitate a variety of daylight in which 80 per cent of the illumination was furnished by direct sunlight. The authors did not appear to realize how little direct sunshine it was possible to obtain in this country. During the year 1911 the amount of sunlight was a record; yet while the total hours of daylight were 4,380, the hours of sunshine were only 1,444—*i.e.*, 33 per cent of the total daylight. There were 170 days which were entirely rainy, and 107 days on which there was no sun. Taking into account the climatic conditions, probably only 7 per cent of the sunlight available would fulfil the authors' conditions of

containing 80 per cent direct radiation; therefore only 2·3 per cent of the total daylight during the year would comply with this requirement. It seemed hardly worth while to suggest conditions which, in this country, could only be met with for such an infinitesimal period of the year.

Mr. Arthur Cunnington referring to the question of economies to be obtained by the use of suitable reflectors, gave an illustration of what had actually been done in this direction.

In a large open office, used for sorting parcels, tungsten lamps had been put in, equipped with steel reflectors of the Holophane-Benjamin type. A similar office of approximately the same area, but lighted with bare lamps, happened to be near by, and the following comparison was obtained :—

	Area (in sq. ft.)	Watts.	Watts per sq. ft	Approx. lighting hours per annum.	Annual cost for current at 1¼d. per unit
New Office	5250	1350	·26	6000	£42
Old Office	5200	2800	·54	6000	£87

The illumination was about the same in each case, between 1 and 1½ foot-candles on the working plane. The net result, it would be seen, was a saving of over 50 per cent, and showed incidentally that an illuminating engineer ought not to be looked upon as an expensive luxury. An interesting feature of this new installation was the opposition it aroused among the workers. They complained that the lighting was bad, because they could not see any bright lamps as in the old office. Measurements with an illumination photometer, however, showed that, although the general effect was admittedly less brilliant, the light on the working plane was as good as before, and more uniform. This incident emphasized the importance of one of the 'Simple Rules of Good Lighting,' recently published in *The Illuminating Engineer** : "Don't judge illumination by the brightness of the lamps."

* *Illum. Eng.*, Lond., Dec., 1912, p. 572.

The speaker also asked if the authors knew of any reflector suitable for use with outdoor inverted gas lamps, and giving a wide distribution such as shown (applying to indoor lamps only) in Fig. 12 (extensive type). There seemed a wide field for such a reflector in the lighting of extended areas such as railway station platforms, warehouses, open sheds, &c. Existing reflectors, said to be suitable for this purpose, either concentrated too much light below the lamp giving "spotty" illumination, or allowed too much to be wasted in the horizontal direction.

Mr. C. C. Paterson (*communicated*) : I think the paper before us, on the use of Shades and Reflectors, is a most useful one, and particularly the section in which the authors deal with the questions of shadows and their intensity. I am very glad that they are making some systematic measurements of the kind which they indicate, since they ought to help to settle a number of vexed questions.

I should like to ask the authors if they think they are quite wise in suggesting that the conditions obtaining in full daylight, when the sun is shining, are really the proper conditions to seek to establish by artificial light. I venture to think that they have not sufficiently taken into consideration the fact that the absolute intensities by daylight are so much greater than they are by artificial light; and if, as they say, a shadow by daylight has 20 per cent of the illumination in full sunlight, this shadow will be far brighter, even to the "daylight adapted eye," than the brightest part of a well-illuminated room by artificial light. If, now, we attempt to make the shadows by artificial light bear the same relation to places which are not in shadow as pertains in daylight, I think we shall find that the shadows have far too low an absolute intensity, with the result that there will be places in the room below the limit of "good seeing," and the effect will be less pleasing than with more complete diffusion. I think, for this and for other reasons, that we ought to endeavour to obtain a greater degree of diffusion by artificial light

than we have by direct sunlight in the open. There is hardly any place, however deep the shadow in the open air, where the illumination is not more than enough for good seeing.

I fully agree, however, that some shadows are wanted in artificial light, but my impression is that this need not be more marked than is the case when a room is illuminated indirectly by *one* central fitting the whole of whose light is reflected on to the ceiling.

I am in full agreement with all that the authors say elsewhere, and congratulate them on the way they have approached the subject.

Mr. P. J. Waldram (*communicated*): In expressing my personal thanks to the authors for a most instructive paper, I would venture to suggest that too much reliance should not be placed upon the reproduction of daylight conditions in artificial lighting. Whilst it is desirable to imitate those conditions as far as possible, it must be recollected that the human eye will submit to intensities of illumination, and also to diversities of illumination, in daylight which cause acute distress under artificial light. The mere fact that in any system we have produced similar intensities and similar sharpness of shadow to those which obtain by day is not, *per se*, a guarantee that the installation is satisfactory.

Mr. W. C. Clinton (*communicated*): In this most interesting series of reflector distribution curves the authors point out the existence of curious peaks in some of them, notably those in Figs. 12a, 13, 14, 15, and 16. These are doubtless due to reflection caustics as they occur most markedly with those shades giving a good deal of regular reflection.

Their presence is liable to lead to error in the photometric measurements, if it is attempted to define the shape of the curve in the neighbourhood of the caustic by observations taken at very small angular intervals. If this angular interval between two successive observations is smaller than the angle subtended by the photometer disc at the source, and if the beam of regularly reflected light has also an angular aperture much smaller than the photometer disc, as may easily be the case, the two readings may both be in excess of the true illumination at these points, although neither gives the actual maximum attained by the reflected ray. The shape of the distribution curve will thus be wrong, although the error made in estimating the total flux of light may not be very great.

The Authors, in reply, expressed their thanks for the many appreciative remarks made during the discussion.

The question raised by the Chairman (Mr. Goodenough) as to whether there was any difference in the power to discriminate colours with one system of lighting as compared with another, using the same illuminant, was an interesting one. Some data had been obtained on this point, but it was thought to be a little premature to introduce the subject into the present paper. Undoubtedly the presence of coloured surroundings might determine the method of lighting to be adopted, especially if colour discrimination was of importance.

Mr. Darch had suggested that insufficient stress had been laid on the use of shades for avoiding glare. The authors pointed out that this had been placed first in the list of the functions of a shade, which was surely giving to it sufficient prominence. Mr. Darch hardly seemed to appreciate sufficiently the *directive* qualities of shades and reflectors. In the majority of practical cases most of the light was required downwards, so that the method advocated by him could scarcely be adopted with efficiency. The illustration of a room lighted by silk shades given in the Appendix (p. 143), and the remarks thereon, aptly illustrated the defects of a system of lighting in which attention was concentrated solely on screening the light. To suggest, as Mr. Darch had done, a shade-brightness of one-tenth candle-power per square inch as the maximum permissible was, the authors thought, going too far. They were of opinion that such data and

specific limiting values were apt to be misleading, as the positions of the light units and contrast effects present played an important part.

With reference to the amount of light to be directed upwards and the amount downwards: in the case where the author suggested 20 per cent and 80 per cent respectively direct methods of lighting were implied, and, therefore, there was nothing to withdraw or explain further on this point. The expression "white glass" was well known in the trade, and was quite distinct from opal. With reference to the point raised by Mr. Darch concerning the quality of the light distributed in the various zones, the authors thought that the data given in the paper was in agreement with Mr. Darch's own views. The difference referred to was, of course, one of area for the respective zones considered; but, whereas their values had been considered from the horizontal, Mr. Darch was apparently considering angular values reckoned from the vertical. One must consider this point in conjunction with the surface to be illuminated.

Mr. Blok has asked for fuller details regarding the tests described in the paper. Such values had been determined, but it was thought that the space available for the present paper did not permit of this section being dealt with fully, and no doubt in the future it would be possible to go into such matters in greater detail. Similar remarks applied to the method of testing employed. On this latter point, however, it might be stated that in all cases a standard distance was maintained between the source under test and the photometer head, and that wherever necessary precautions were taken to avoid errors due to the source under test and the standard having different colour-values.

Mr. Blok and Mr. Clinton remarked on the "peaks" present in some of the polar curves, and their comments with reference to them were interesting.

Mr. Blok and Mr. Campbell had referred to the need for correct centering of the light source in a particular shade or reflector in order to obtain a definite polar distribution curve. This was a matter of some importance, but from tests made by the authors it was found that, with modern illuminants being, as they were, of material size, and not "point-sources," serious difficulties from the practical standpoint were not met with. Moreover, lamp-makers and the manufacturers of shades and reflectors were coming to a better understanding on this point, and it was a comparatively easy matter for them to comply with the lamp conditions requisite for the production of correct distribution curves. The definite loss in light referred to by Mr. Blok in the case of one test should not be possible to a material degree under ordinary circumstances.

Mr. Bailey and Mr. Harrison had referred to bowl lighting, and it was in the authors' minds that there were possibilities in this direction when they suggested in a section of their paper that there was room for improvement in direct lighting units, and that, perhaps, too much stress had been laid upon indirect lighting. The authors agreed that a great deal could be done with specially prepared paper and linen, but it must be realized that there were always difficulties in commercializing goods that it was not possible to protect from imitation. Also, while such units might be indestructible as regards breakage, it would be difficult to keep them clean; and although one might keep them once they were purchased, so soon as they were dirty they would soon become useless both from the lighting and decorative standpoint. Easy maintenance was an important matter, and should always be provided for.

Prof. Morris's reference to oil lamps was endorsed by the authors, and they remarked that the shape and position of reflectors and globes used with these lamps seemed to be determined in a very casual manner; the same thing had been pointed out in the discussion on the papers on 'Acetylene and Petrol Air Gas.'

Mr. Wheat had remarked that the authors would admit that the greater the amount of the light reflected, and the lesser the amount coming direct,

the better the shadow effect. They, however, could not agree with this statement without qualifications. It was impossible to obtain a well-defined shadow with indirect lighting, and they contended that there were instances where definite shadows were preferable. At the same time they agreed that there were also many cases where the particular effects produced by indirect lighting were an advantage. Mr. Wheat and Mr. Ritchie referred to daylight, and in particular to sunlight, and showed how little was obtained in London. But the authors could not agree that the data brought forward implied that the kind of illumination produced by sunlight was unsuitable. The figures presented were interesting, but it must be remarked that what applied to London could not be taken as a standard for the whole world; nor could London be taken as the ideal spot from a lighting standpoint.

Mr. Wheat referred to cloudy daylight, and remarked that members of the Society knew that a source of light was not meant to be looked at; but the authors had made it clear in their paper that, with cloudy daylight conditions, the size of the source was so great that it was impossible to avoid seeing the bright clouds, and that it was on this account that direct sunlight with a rich blue sky was less glaring for all normal positions of the eye. In short, a properly arranged installation of direct units will, in most cases, give all that is desired, and the objection usually raised to the direct system, namely, the visibility of the subdued light-sources, is not well founded.

With reference to the remarks communicated by Mr. Paterson and Mr. Waldram, both touched upon the same subject, but from different aspects. It might not be advisable for artificial light to reproduce exactly daylight conditions. At the same time, the authors would suggest that investigations on daylight would lead to some useful information which could be applied, at least in some measure, to artificial systems. The experiments carried out, and experience obtained up to the present, did not lead them to adopt Mr. Paterson's view, that a single indirect unit placed in the centre of a room would give the most desirable shadow effects. Moreover, artificial lighting was, in general, required for more than one purpose, and indirect methods were less efficient than direct ones.

Mr. Cunnington, the authors thought, had put forward very practical and serviceable data. At the present moment it was difficult to get comparative data of this kind from users of illumination, and it was specially desirable to secure particulars of the effect of improved illumination, and the ease and convenience with which work could be done. They hoped that engineers and others would bear this in mind, and bring before the notice of the Society cases in which improved illumination had led to a definite improvement in the work produced and a reduction in the cost of maintenance. It would be good, too, if the Society could find means of bringing such data to the notice of the general public, as the result would undoubtedly benefit the whole lighting industry.

Royal Institute of Public Health Annual Congress.

The Annual Congress of the Royal Institute of Public Health is to be held in Paris during the Whitsuntide Holidays, May 14th to 18th inclusive, under the patronage of the French Government.

A special section dealing with industrial hygiene has been arranged, over which Sir Thomas Oliver will preside. A discussion on Lighting as a Health Factor in Occupation and its Influence on the Prevention of Accidents, will be opened by Mr. Leon Gaster.

The Annual Dinner

OF THE

Illuminating Engineering Society.

(Founded in London, 1909.)

THE ANNUAL DINNER was held at the Trocadero Restaurant in London, on Monday, February 10th, the President, PROF. S. P. THOMPSON, F.R.S., being in the chair.

Early in the proceedings the Hon. Secretary was called upon by the Chairman to read some of the messages of regret received from those who were unable to be present. The Presidents of the Royal Society, the Royal Institute of British Architects, and the Royal College of Surgeons had all written regretting their unavoidable absence. He had also communications from Mr. Leonard Stokes and Mr. Ernest Newton on behalf of the R.I.B.A., from Lord Saunderson (Chairman of Council of the Royal Society of Arts), Sir William Abney, Mr. Blair (London County Council), and the Chairman of the Royal Sanitary Institute.

Sir Corbet Woodall had been obliged to decline the invitation on the ground of indisposition, and Mr. Edward Allen had very kindly consented to represent the Institution of Gas Engineers instead. Sir Henry Trueman Wood, a Vice-President and valued friend of the Society, had sent a message expressing his appreciation of its continued prosperity.

Sir Boverton Redwood wrote: "I regard the invitation as a compliment, and wish I could have testified by my presence to my high appreciation of the value of the services rendered to the science of lighting by the Society."

In conclusion, Mr. Gaster expressed satisfaction with the good attendance. To have secured a gathering of nearly eighty was, in view of the comparatively small number of members residing in London, distinctly satisfactory. The numbers present at the Dinner were growing year by year, and would, he hoped, be much larger in years to come.

Toast: "The Illuminating Engineering Society."

After the usual loyal toasts, MR. FRANK BAILEY proposed "The Illuminating Engineering Society." The Society, he said, had already received support in many quarters. Yet it had occurred to him that the membership did not include every one necessary to bring its efforts to a successful conclusion. For instance, he thought we might look to the time when glass makers and fittings makers would join the Society in greater numbers, and possibly read papers at the meetings. In the utilization of light many people were concerned; another section of the community largely interested being the architects, whose support was also needed. The very great progress recently made in all methods of lighting gave reason for congratulation. To-day a great improvement in efficiency was achieved by the use of gas under high pressure. Who could say but that to-morrow we might be compressing oxygen and suitable hydrocarbons, and, by impinging it on a block of some other refractory material, obtain a light which would surprise everybody? Improvements were likewise constantly being made in the use of electricity, acetylene, and petrol air-gas.

The Illuminating Engineering Society had an enormous field of work to cover. Not long ago Mr. Duddell, the President of the Institution of Electrical Engineers, made the remark that we,

as a nation of shopkeepers, were coming to be known as a nation of scientists. That was true, and it seemed to offer great hope for our future prosperity. The nation that had at its command most scientists must undoubtedly outshine others with less resources. Quite apart from its industrial triumphs, science was of value as an intellectual solvent. When scientific men met together to discuss technical subjects they sought to break down the small ideas which might otherwise prevent them working together; science encouraged us to look forward to a time when the bonds between kindred societies in various countries would be drawn closer than at present, so that all might meet on common ground.

In this respect the Illuminating Engineering Society had more than justified its existence. It had already been represented, in the person of its indefatigable Hon. Secretary and others, at a number of international congresses, and it was upon such efforts as these that the prosperity of the nation would in future largely depend. The technical and learned societies of this country, by meeting the kindred societies of other nations, could do much towards breaking down that barrier of insular prejudice which occasionally amounted almost to arrogant exclusiveness in this country. By such means—by establishing common ideas and sympathies between the individuals of different nations—we could do much to safeguard the peace of Europe. Men of science were among the most influential peace-makers of the present day. The strength of a nation did not depend merely on the maintenance of a vast army and navy, but upon its science, industry, and capacity for assimilating new ideas. Six European nations were spending annually 207 million pounds in preparing to destroy life. What could not our Society do with a half per cent of this sum! If such a Society as this, with its conflicting interests, could assemble its members in friendly discussion, surely a similar policy was not impossible throughout the whole world.

In conclusion, Mr. Bailey referred in appreciative terms to Prof. Thompson, who, he said, as an "illuminator" ranked supreme, inasmuch as he had such a happy and unique gift of making all things clear. He had the greatest possible pleasure in coupling with the toast the name of Prof. S. P. Thompson.

The President, in replying to the toast, expressed his appreciation of the hearty manner in which it had been received. He thought everybody would agree that the Illuminating Engineering Society was in a flourishing state. In the three years of its existence the membership had grown to more than 400, and they might justly claim to have been successful during this period in making their subject and themselves known to, at any rate, a large section of the public. They had succeeded in impressing upon a number of influential people that there *was* such a thing as the science of illumination; and they were gradually paving the way for a much wider understanding of that subject on the part of the British public.

But they had performed other functions besides that of merely discussing illumination and reading papers upon it. Mr. Bailey had referred to one of the most important aims of the Society, namely, that of bringing together in one harmonious gathering a number of persons who represented interests which, outside the circle of the Society, could not but be regarded as conflicting and rival interests; and yet there had never been any trouble within the Society from this fact, because, behind all this rivalry, there existed a common thing in which they all had interest, and about which they were very friendly rivals, namely, the subject of the proper supply and distribution of light. It was necessary to teach the public to recognize the real distinction between good lighting and bad lighting; so many did not know bad lighting when they saw it, and so many mistook too much lighting for good lighting. They would have to induce the L.C.C. to do that good thing which in certain other not very distant parts had been done, namely, to compel the advertising shopkeepers to guard the street side of their lights from producing too

much glare in the street. It was all very well for pushing shopkeepers to throw abundance of light on to their shop fronts, but they must not be allowed incidentally to dazzle the drivers of vehicles using the roadway. The most important part of the work of the Society was to make the people understand that they could see better with less light, and that, in many cases, they were throwing half of it away in glare.

He hoped in twelve months' time they would be able to make some progress in another direction. They were honoured that evening with the presence of one or two gentlemen who were architects, and he wished they had more. If architects only knew how much they had yet to learn on the question of illumination they would be the best friends of the illuminating engineer. He had made the remark more than once that very few of us knew, not only our own ignorance, but how much there was on which we were ignorant. There was not one person that evening who did not feel that he had learnt a great deal on the question of illumination and good lighting by having been brought into contact with the Society. There were things that they had had to learn, and possibly things they had had to unlearn. Not only had the Society enjoyed a good year since the last Annual Dinner; not only had it added active members and Committees, and active writers of papers, and keen discussions; not only had there been activity within the borders of the Society, but it had been producing effects beyond. It was pleasing to know that the International aspect of the movement was not standing still. There had been distinct progress in the reconstruction of that body known as the Zürich Committee, which was now become a truly international body concerning photometric units and all that was involved therein. He hoped that aspect of the work of the Society would duly impress itself upon the members.

At home also there were distinct signs of progress, which certainly must be taken as encouraging. Among the guests that evening was Sir Arthur Whitelegge (Chief of the Factory Department at the Home Office), and they had recently learnt that Sir Arthur and those associated with him had taken an important part in the appointment of a Departmental Committee to inquire into the better lighting of workshops and factories, a Committee which was to be under the conduct of Dr. Glazebrook. All this showed that in official, as well as in unofficial circles, the matter for which they existed, namely, the study of the progress of lighting, was becoming recognized as a thing requiring, not only inquiries, but something in the way of legislation. It must be brought home to employers and owners of factories and workshops who have not, in their own interests, found it out, that they must properly light the tools and benches and workshops; that the places where men work must not be so badly lit as to cause eyestrain or detriment either to the health or wealth of the workers. Whenever the step was accomplished of being able to bring legal pressure to bear upon defaulting employers of labour, then he maintained that a good deal of the work which the Society started out to accomplish will have been done; but he hoped it would not end there, whenever that might be.

It was stated that the fourth and fifth years of a society's existence were its critical years. The Illuminating Engineering Society had yet to cut its eye-teeth, but he ventured to think that it would come successfully through this period, and that it would still have many problems to deal with, because science was never standing still, and its applications were ever widening. He felt that the Society had only just begun its work, and was nowhere near ending it.

Toast: "Kindred Societies."

Mr. F. W. Goodenough (Chairman of Council) next proposed "Kindred Societies." He did so, he said, with the greatest pleasure, because it was a toast which peculiarly commended itself to the Society, inasmuch as the Illuminating Engineering Society was in an exceptional degree, as a technical society, dependent for the ultimate

success of its propaganda upon the co-operation of other societies. As Prof. Thompson had pointed out, they were aiming at the determination of what was adequate and scientific lighting on the one hand, and the creation of a demand for scientific lighting on the other. For the achievement of that object they needed the general public, and, as a scientific society, they could only reach the general public through the members of those societies to which the public looked for guidance on matters economic and hygienic. Therefore, it was only by relieving the members of those societies from the profundity of their own ignorance, as mentioned by Prof. Thompson, that they could hope to educate the people and get them to expect scientific lighting.

The Society also was dependent upon other institutions, comprising those engaged in the generation of light (whether gas, electric, or any other illuminant). It was dependent upon them largely for research into the application of light in a scientific manner, and trusted to the members of these various Societies becoming members of the Illuminating Engineering Society, which formed the common ground upon which they could all meet. To himself one of the great pleasures of belonging to the Illuminating Engineering Society was that he could, by attending its meetings, fraternize with members of professions with whom he was in friendly rivalry on other days of the week. Certainly his membership of the Society had brought him many personal friends amongst the ranks of those who were supposed to be his enemies. He coupled the toast with the names of Mr. W. Duddell, the President of the Institution of Electrical Engineers, and Mr. E. Allen, senior Vice-President of the Institution of Gas Engineers; incidentally, they would all regret the absence of Sir Corbet Woodall, under doctor's orders, and also the absence of Sir William Abney, whom they had hoped to see present. He further coupled with the toast the name of Dr. Lawford, President of the Ophthalmological Society.

Mr. W. Duddell (President of the Institution of Electrical Engineers), responding to the toast, referred to the question of co-operation with other societies. He was quite in agreement that the only way in which technical societies could do their work properly was by co-operation, and he was able to say on behalf of the Institution of Electrical Engineers that it was the desire to co-operate in every possible way with the Illuminating Engineering Society. It was felt that, by the proper consideration of illumination and the proper distribution of light, benefit would accrue to all parties, whether they were concerned in burning gas in the atmosphere, or stimulating the filaments of lamps by electricity, or using electricity in vacuum tubes.

What was required was good illumination, and by this he did not necessarily mean perfectly uniform illumination without any shadows, but an illumination which was pleasant. There was no doubt that the Illuminating Engineering Society was doing a very good work in finding out what was the right form of illumination, and the electrical engineers would do their part and find means for creating proper sources of light when the Illuminating Engineering Society had demonstrated the right sort of illumination to have from the point of view of comfort and health. Mr. Bailey had referred to the possibilities of compressed oxygen. He hardly knew whether this was to be classified as gas lighting; but, if so, he thought it possible that electrical engineers might invent some other form of gas, the molecules of which would be constantly re-created in some way, and thereby give a still higher illumination. He had a great belief that gas, not treated by burning it in the air, but stimulated by electric discharge, might be the illuminant of the future. There seemed to be a better chance of getting a high illuminating efficiency from gaseous sources than by any other form of illuminant.

Mr. E. Allen (senior Vice-President of the Institution of Gas Engineers), who also referred to the regrettable absence of Sir Corbet Woodall,

expressed his thanks for the manner in which the toast had been received. Something had been said that evening on the friendly rivalry between gas and electric lighting, but he was glad to think that this rivalry had been of benefit to both illuminants, and that both could exist side by side. At each stage in the development of gas an advance in electric lighting had brought about a similar improvement in the other camp: it was through rivalry of this kind that progress was made.

He was in full agreement as to the good work being done by the Society by promoting co-operation between those interested in various forms of illumination. When he was invited, some years ago, to become a member of the Society, he had not seen his way to do so, but since then the Society had reached such a commanding position in the world of illumination that he would now esteem it an honour to be invited to join.

Dr. Lawford (President of the Ophthalmological Society) said that the Ophthalmological Society was extremely interested in the practical applications of illumination, and more especially in the lighting of schools and educational institutions for children and young people, and also in the illumination of workshops and similar places. It was of the greatest assistance to the members of his Society to be able to consult illuminating engineers, and to obtain help in technical details which were outside their immediate province. Members of his Society would be only too pleased to continue to avail themselves of this assistance.

There was one direction in which it seemed the Illuminating Engineering Society could do a great deal of good, and that was in mines. For example, with a view to preventing as far as possible the disease of the eyes known as miners' nystagmus. Mining was particularly a branch of industry in which we could, with Goethe, ask for more light, but in this respect their efforts should be directed towards utilizing the amount of light already possessed with the greatest possible advantage.

Toast: "Our Guests."

The toast of "Our Guests" was next proposed by the Hon. Secretary, Mr. L. Gaster, who referred to the offer recently received from the London County Council to allow the use of certain schoolrooms for experimental lighting with gas and electricity. The London County Council had rendered great assistance in another direction, namely, by making arrangements for courses on illuminating engineering at three colleges; and it was in respect of this assistance that they particularly welcomed that evening Sir Laurence Gomme, Clerk to the London County Council, through whose good offices these results had been obtained.

It might be interesting to recall that he had approached the London County Council as far back as 1906 on this subject, but at that time little further was done, mainly because there was a difficulty in finding people able to give instruction in illuminating engineering. But when the time was ripe, and the movement further advanced, he had again broached the project, and the present courses were the result. He would like to suggest, however, that in future these courses might form a definite part of the college curriculum: the satisfactory attendance secured in the present circumstances (when the course was optional and an extra fee asked) showed the demand for information on illuminating engineering, and this was a field in which there would be ample opportunity for employment in the future.

He also wished to couple with the toast the name of Sir Arthur Whitelegge, H.M. Chief Inspector of Factories, through whose active co-operation the Committee on the Lighting of Factories and Workshops had been appointed. It was also due to the interest which Sir Arthur Whitelegge had taken in the subject that the Home Office had been officially represented at a number of Continental conferences last year. Here again the step of appointing a Committee on Illumination had been the result of a gradual evolution. The events at the Congress on Industrial Hygiene in Brussels in

1910, and the subsequent International Congress for the Prevention of Industrial Accidents in 1912, had brought home the need for good lighting in many different quarters, and after due deliberation the need for an inquiry became manifest.

Another guest whose presence they much appreciated, Dr. Glazebrook, was the Chairman of the Committee on Illumination already referred to. Dr. Glazebrook was also known to them as the Director of the National Physical Laboratory, where so many accurate researches on photometry had been carried out. The Government laboratories in France, Germany, and the United States, as well as the National Physical Laboratory in this country, had done exceedingly valuable work in connexion with the relations between the units of light used in different countries. All would agree as to the importance of the simplification recently arrived at, by which three of the above countries now employed the same unit.

The Illuminating Engineering Society that had just come into existence in Germany was formed under the auspices of the Technische Physikalische Reichsanstalt. He hoped that the National Physical Laboratory would likewise give its sympathy and support to the illuminating engineering movement in this country.

Sir Arthur Whitelegge (H.M. Chief Inspector of Factories), in replying, commented upon the general ignorance in matters of illumination, and expressed his gratitude to Mr. Gaster for his appreciative reference to the work which the Home Office was now doing. The Departmental Committee was now about to enter upon its duties; indeed, it was starting at 2.30 on the following day. It was evident that they would have to consider a vast variety of questions which presented themselves in the different branches of industry. They would be concerned with every branch of industry that came within the wide range of factories and workshops, and in this connexion they would have the fullest advantage of the splendid work that had already been done, and which he was confident would continue to be done, by the Illuminating Engineering Society.

Sir Laurence Gomme (Clerk to the London County Council) also responded, and dwelt upon the necessity for making the movement towards a better appreciation of good lighting an international one. Our civilization was, he said, the stupidest sort of civilization that ever the world had known, for we drew fences round our different centres instead of opening up our interests and knowledge of what the world produces. He was glad to think that the Illuminating Engineering Movement, by creating sympathy between workers in different countries, was helping to break those barriers down.

Toast: "The Chairman."

Dr. R. T. Glazebrook, F.R.S., briefly proposed the final toast, "The Chairman," who, he said, was so well known to them all that he needed little recommendation. He could appreciate to the full the advantage to the Illuminating Engineering Society in having Prof. Thompson as its President in the early stages. He himself would now be brought in close touch with lighting problems in connexion with the newly appointed Committee, which had very heavy, but valuable work before it.

Prof. Thompson, in reply, expressed the hope that the work of the Society would do something towards the promotion of a better understanding between conflicting parties, not only in this country, but in other countries. During the past few years, in the electrical industry, the immense advantage of good international relations with other countries had been manifest, and that same stage had now been reached in regard to illuminating engineering. But we had only just embarked upon international agreement in matters photometric, and he hoped that in the future a fuller understanding would be reached.

160A.

Photo by J. Jacks & Co., 213, Regent Street, London, W., from whom additional copies may be had on application.

Mr. M. L. Hepburn, F.R.
Mr. J. Herbert Parsons, F.R.C.S.
Mr. J. B. Lawford (*President of the Ophthalmological Society*)
Mr. W. Duddell, F.R.S. (*President of the Institution of Electrical Engineers*)
Dr. R. T. Glazebrook, C.B., F.R.S. (*Director of the National Physical Laboratory*)
Sir A. Whitelegge, K.C.B., F.R.S. (*H.M. Chief Inspector of Factories*)
Prof. S. P. THOMPSON, D.Sc., F.R.S. (Chair)
Sir L. Gomme (*Clerk to the London County Council*)
Mr. E. Allen (*Vice-President of the Institution of Gas Engineers*)
Mr. F. W. Goodenough Mem. Inst. Gas Engineers (*Chairman of Council of the Illuminating Engineering Society*)
Col. W. F. Lees
Lieut.-Col. Wilton

Mr. F. W. Willcox
Mr. J. P. Gregory
Mr. W. R. Rawlings
Mr. G. Ryan
Mr. A. Stokes
Mr. C. Franks
Mr. W. J. Liberty
Mr. A. E. Podmore
Mr. E. Scharrer
Mr. R. Henke
Mr. H. A. Jacoby

Mr. J. Darch
Mr. F. P. Driver
Mr. E. G. Sheppard
Mr. Brinkmann
Mr. G. Harrop
Mr. O. Krupka
Mr. C. Fisher
Mr. Russell
Mr. A. E. Ernst

Mr. A. Trotter
Mr. C. Beck
Dr. A. H. Levy
Mr. J. G. Clark
Mr. T. E. Ritchie
Mr. H. C. Wheat
Mr. B. J. Grigsby
Mr. G. Campbell
Mr. H. T. Harrison
Mr. F. Walker

Mr. A. Webster
Mr. D. R. Wilson
Mr. C. C. Paterson
Mr. Peto
Dr. H. R. B. Hickman
Mr. K. Edgcumbe
Mr. Cousens
Mr. S. T. Dobson
Mr. F. Bailey

Mr. G. W. Bennett
Mr. O. Macfarlane
Mr. S. Davis
Mr. H. E. Goody
Mr. Scheff
Mr. F. Shaw
Mr. J. H. Asdell
Dr. A. Gaster
Prof. D. A. Louis

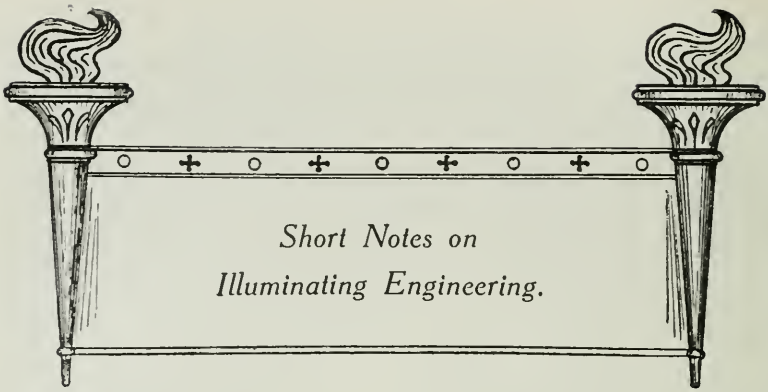
Mr. C. Wilson
Mr. E. Lovinson
Mr. L. H. Jones
Mr. E. Nash
Mr. M. Foulds
Mr. W. E. Bush
Mr. G. Herbert
Mr. S. D. Chalmers
Mr. G. M. Lloyd
Mr. J. S. Dow
Press Association

Mr. J. Wyatt Ife (*Hon. Treasurer*)
Mr. R. J. Wallis-Jones
Mr. L. Gaster (*Hon. Secretary*)

ANNUAL DINNER OF THE ILLUMINATING ENGINEERING SOCIETY,

Held at the Trocadero Restaurant, Piccadilly, London, W., Monday, February 10th, 1913.

(The positions are in accordance with the photograph on the opposite page).



GOOD EDUCATIONAL WORK BY THE AMERICAN MUSEUM OF SAFETY.

VALUABLE work is being done by Dr. W. H. Tolman at the American Museum of Safety in New York.

On November 7th, 1912, the Board of Education assented to a resolution arranging for co-operation with schools in the form of lectures, &c., with a view to pointing out to the children the precautions to be taken in avoiding accidents from vehicles in the streets. It is stated that in the six months ending last September, during which instruction in this subject has been introduced in the schools of New Jersey, the number of accidents to school children in the State diminished by 44 per cent. In view of the agitation in London regarding street accidents, this step is worthy of notice. One of the causes of such accidents is the imperfect method of lighting adopted in some streets. Every effort is made to increase the illumination. But has the dazzling effect of brilliant lights been sufficiently appreciated yet ?

NO LIGHT IN ADRIANOPLE.

IT appears that the occupants of Adrianople have been having a bad time, provisions having reached a very low ebb. A recent Central News message concludes an account of the distress in the fortress by the culminating announcement :—

" Adrianople is entirely without light during the night."

ELECTRICITY FROM THE VILLAGE STREAM.

WE notice in *The Daily Mirror* an account of what is apparently the smallest village in the United Kingdom to have an electric lighting station of its own, namely, Kettlewell, near Grassington.

The village has only seventy-seven houses and about 300 inhabitants, but its chief citizens have devised a scheme of using the Kettlewell Beck (a local stream) to provide electricity. It is calculated that, even in the driest weather, the stream will produce enough electricity to supply 400 twenty-five c.-p. lamps. A capital of £625 has already been subscribed, and the cost of the light to users is expected to be 6*d*. a unit.

The above illustration is a daylight photograph reproduced from an article in an American contemporary on the applications of electricity in the factory. The row of bare lamps in line with the workers' eyes suggests that one important application—illumination—has not been sufficiently studied !

NEW LIGHTING DEVICES ON THE UNDERGROUND RAILWAYS OF LONDON.

The enterprising methods of lighting adopted by the Tubes and Underground railways of London are always interesting. The convenience of the system of illuminated notices, showing at a glance the destination of the next train, has been firmly established, and is now being introduced in many suburban stations. One of the most effective recent installations of this kind is at Finsbury Park (London, N.), where the complexity of the service is apt to be bewildering to passengers unfamiliar with the station.

Another novelty to be seen at some of the Underground stations (for example, St. James's Park) is the use of concealed lighting to illuminate the names of the stations and cause them to stand out strongly—a device which is particularly needful in these days of pictorial advertisements. At Waterloo Station and elsewhere an effective intimation of the whereabouts of the Bakerloo tube is provided by a large box with translucent sides, bearing the name of the railway, and strongly illuminated by a flame arc placed inside.

The characteristic of all these devices is that the lamp itself is hidden, but its light is effectively utilized for the purpose in view.

CLASSIFICATION OF ACCIDENTS.

Mr. E. S. Lott, President of the United States Casualty Co., of New York, read a paper on this subject before the Chicago Conference of the American Association for Labour Legislation on September 15th last, in which he emphasized the importance to insurance companies of classifying accidents. Information on this point is of immense value to the State and to insurance companies, whose function it is, in their own interest, to *prevent* accidents. Yet, in spite of the volume of statistics collected, little has yet been done to ascertain and record the causes to which each accident is due.

Mr. Lott suggests a series of a dozen main causes, one of the most important of which is *insufficient lighting.*

FATALITY THROUGH THE EXTINCTION OF A PUBLIC LAMP.

A recent number of *The Journal of Gas Lighting* mentions the case of a carter who was pinned between the shafts of a waggon and a fence when leading his horse in a very dark and narrow road in West Bromwich. It is stated that the public lamp at this spot was out at the time of the accident; the carter did not observe the depression in the road into which one of the wheels of the waggon sank, causing the vehicle to swerve on one side.

For the time being it is not evident how the lamp came to be extinguished. The inspector stated that it was lighted every afternoon at half-past four, and that he always paid special attention to this matter, knowing the dangerous nature of the road. The jury recognized the importance of efficient lighting in these circumstances, but also recommended that the road should be widened.

HOW TO WIRE CURVED ELECTRICAL FITTINGS.

Much time is sometimes wasted in wiring curved electrical fittings, and it is often no easy matter to get the wire round the sharp bends. A simple time-saving method in such cases is to use a heavy shot in which a nick is cut. The wire is inserted through the nick, and the shot is then allowed to run down the pipe, carrying the wire with it.

Good reading posture. Good reading posture. Very undesirable reading posture. Undesirable reading posture.

FIG. 1.—Daylight illumination.

FIG. 2.—Manner in which a table lamp may be used.

MINIATURE LIGHTING INSTALLATIONS.

An ingenious method of showing lighting effects recently described in a lecture by Mr. P. S. Millar before the New York Companies' section of the National Electric Light Association.

IN this lecture Mr. Millar attempted to sum up the art of illumination in a nutshell, as follows :—

"*To render visible the things which it is desired to have seen; to establish hygienic conditions for vision; to conform to æsthetic requirements; and to accomplish these things with reasonable economy.*"

To illustrate modern methods of lighting, he contrived a number of miniature rooms, each 4 ft. square and $3\frac{1}{2}$ ft. high, in which minute lamps and fixtures, toy furniture, and small dolls—to represent human beings—are placed. In this way the effects of different styles of lighting, the resultant distribution of illumination, and the right and wrong positions for reading, could be clearly demonstrated. A few photographs of these arrangements are reproduced in Figs. 1, 2, and 3.

This method, although requiring a little extra trouble on the part of the lecturer, is one that should appeal strongly to a popular audience. In illuminating engineering an effective appeal to *the eye* is often better than the most elaborate verbal explanation.

Indirect. Semi-Indirect. Direct.

FIG. 3.—Three common methods of illumination.

TRADE NOTES.

[At the request of many of our readers we are extending the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

Some B.T.H. Installations.

From the **British Thomson-Houston Co.** (Mazda House, Upper Thames Street, London, E.C.) we receive, as usual, particulars of quite a number of recent installations.

In the account of the lighting of a city bank and a modern hospital special reference is made to the soft illumination secured by the "Eye-rest" system. In the hospital special local lighting methods had also to be employed, and in the operating theatre a special fitting, giving an illumination on the table of as much as 30 foot-candles but no harsh shadows, was contrived by the joint efforts of the architect, the electrical contractors, and the B.T.H. staff.

We are also favoured by an account of the lighting of the Lime Street Picture House, Liverpool. In cinematograph theatres the problem of lighting long and low rooms can be met by indirect lighting, which, it is said, besides avoiding glare, does not impair the appearance of the pictures, even if the lights are kept on.

One of the other articles before us describes an illuminated "Mazda" sign at Victoria Station. The board is 28 ft. long and 6 ft. deep, and is lighted by forty Mazda lamps concealed in special reflectors. A striking and even illumination over the face of the board is secured.

The other chief item of news, which reached us too late for insertion in our last number, is the completion of the new factory at Willesden, which, we understand, is now in full swing.

Osram Expansion.

Owing to the large increase in the sales of Osram lamps since their manufacture with Drawn-wire Filaments, the **General Electric Co., Ltd.,** have found it necessary to provide for additional facilities for handling orders.

A larger space at their head office—67, Queen Victoria Street, E.C.—is now devoted to the sale of Osrams, the counter-room has been doubled, and the new counter, which is adjacent to the old one, has been specially reserved for supplying the following: High Candle-power Osram Lamps, all types of Round Bulb Osram Lamps, Fancy Osram Lamps, Candle Osram Lamps (both twisted and plain), Spearhead and Shadoless types Osram Lamps, Osram Tubular Lamps, Osram Striplite Lamps, Osram Battery Lamps for Motor-car Lighting and other purposes.

The Mazda Sign at Victoria Station.

Dining Room of Cavendish Club, Piccadilly, lighted by Mazda Lamps and Holophane Reflectors.

Personal.

Messrs. Siemens Bros.' Dynamo Works, Ltd., inform us that Mr. H. S. Kennedy has been appointed to the position of Marine Manager of the Marine Department of the Company, and will now be stationed in Glasgow. His friends will congratulate him on this new appointment.

Messrs. Strode & Co. (48, Osnaburgh Street, London, N.W.) inform us that this business has been incorporated as a Private Limited Liability Co., under the title of Strode & Co., Ltd. The business will still be carried out under the management of Mr. D. M. Strode and G. W. Strode, with the same staff.

Venner Signs on the L.C.C. Tramways.

We are informed that, on July 30th last, the Council decided that numbers should be attached to cars indicating the route. The Highways Committee has now decided that these should consist of plates manufactured by Venners Signs, Ltd.

Catalogues Received.

From the **A.E.G. Electric Co.,** particulars of Ægma drawn-wire lamps and Holophane Stiletto reflectors; **British Prometheus Co., Ltd.,** Prometheus electric heating and cooking appliances.

The Economic and Hygienic Value of Good Illumination.

A paper on this subject was read by Mr. Leon Gaster before the Royal Society of Arts (London), on February 5th, Sir Arthur Whitelegge, H.M. Chief Inspector of Factories, being in the chair. An interesting discussion ensued, in which a number of members of the Illuminating Engineering Society took part. Restriction of space prevents our dealing with the paper in this number, but we hope to do so shortly.

The complete paper and discussion was published in the *Journal* of the Royal Society of Arts for February 7th, 1913.

Review of the Technical Press.

ILLUMINATION AND PHOTOMETRY.

Recent numbers of the *Transactions* of the American Illuminating Engineering Society are devoted to papers read at the Annual Convention in 1912, which have been already noticed in this journal.

E. P. Hyde (*Elec. Rev.*, N.Y., Feb. 1) gives an account of an instrument for reading "watts per C.P." direct, devised at the Physical Laboratory of the National Electric Light Association; and R. F. Pierce (*Elec. World*, Feb. 8) describes a **new method of arranging polar distribution curves,** the candle-power values being plotted on one side of the diagram, and the flux on the other.

The *Journal f. Gasbeleuchtung* publishes a notice of the formation of the Illuminating Engineering Society in Germany, including the names of a series of influential supporters, many of whom are also members of the British Society. The first meeting was held in Berlin on Feb. 24th.

Turning to more popular articles, we note a readable account of references to **Light in Mythology and Religion,** in *The Edison Monthly*; some reproductions of famous illustrations and engravings, representing the triumph of light over darkness, are also given.

Reference may also be made to an article by W. D. Bancroft (*Jour. Franklin Inst.*, Feb.). He deals with **Chemical Production of Light,** classifies the various kinds of luminescence, and gives a very complete series of references.

ELECTRIC LIGHTING.

The articles on electric lighting do not contain any very novel matter. J. C. Pole gives a general account of the **Quartz Tube Mercury Vapour Lamp** (*Elec. Rev.*, N.Y., Feb. 8), in which the construction and starting characteristics of the lamp are illustrated. W. Fennel (*Elec. Rev.*, Feb. 14) gives some figures for the cost of **Outside Shoplighting by Arc Lamps,** and suggests some methods of charging likely to induce merchants to install such lamps.

An interesting account of an Edison battery outfit and **Portable Lamp for Mines** is given in *The Electrical World* (Jan. 25). The lamp has gained the Rathenau Medal of the American Museum of Safety. The battery weighs about 2 lb., and will give 4 amp.-hours, and the lamp used is rated to give 2 c.-p.

Recent serial articles in the *Zeitschrift für Beleuchtungswesen* on progress in glow lamps are devoted mainly to new methods of evacuation, also novel forms of lamp-filaments and bulbs giving a focussing effect.

GAS LIGHTING, &c.

Perhaps the most interesting item in this section is the announcement of an improvement in the Keith high-pressure lamps consisting in a very small and **compact Quartz Glass Globe,** which can be arranged to come quite close round the mantle. This gives an improvement of 10 per cent in efficiency, and greatly reduces the overall dimensions of the lamps; the new globes are also said to be very durable, and will not break if the mantle gives way and the flame flashes through.

G. Himmel (*J.f.G.*, Feb. 8) deals with methods of **suspending High-pressure Lamps over the Centre of the Roadway,** and arranging for them to be lowered when necessary to receive attention. He gives a summary of the chief requirements with which such an arrangement must comply to be successful in practice.

C. H. Wordingham (*J.G.L.*, Feb. 11) contributes an article pointing out the advantages of **Combined Gas and Electricity Supply**—an article which has aroused much comment in the press. Surely a sign of the times!

Several recent articles on acetylene deserve attention. The *Zeitschrift für Beleuchtungswesen* describes some portable lamps and motor headlights; and the *Acetylene Lighting and Welding Journal* gives an account of automatic unattended signal lights. Reference is also made to a new **Acetylene Signal Gun**, which can be fired automatically at intervals of half a minute. Attempts are being made to control the operation of this from the shore by wireless means.

List of References:—

ILLUMINATION AND PHOTOMETRY.

Amerio, A. Fondamenti e propessi della tecnica dell' illuminazione (*atti della Assoc. Elettrotecnica Italiana*, Feb. 15).
Bancroft, W. D. Chemical Production of Light (*Jour. Franklin Inst.*, Feb., 1913).
Benford, F. A. Theory and Calculation of Illumination Curves (*T.I.E.S.*, Dec., 1912).
Campbell, G. Factory and Works Illumination (*Elec. Times*, Feb. 20).
Coblentz, W. A Radiometer attachment for a Monochromatic Illuminator (*Jour. Franklin Inst.*, Feb.).
Editorial. An Instrument for Measuring Watts per C.-P. (*Elec. Rev.*, N.Y., Feb. 1).
Graphic Representation of Light Distribution (*Elec. World*, Feb. 8).
Hyde, E. P. A Watt per C.-P. Meter (*Elec. Rev.*, N.Y., Feb. 1).
Lasser, F. Modern Railway Station Lighting (*A.E.G. Journal*, Feb.).
Pierce, R. F. A Rational Method of Showing Light Distribution (*Elec. World*, Feb. 8).
Light Creative (*Edison Monthly*, Feb.).
Federal Prismatic Signs (*Elec. Rev.*, N.Y., Feb. 8).
Deutsche Beleuchtungstechnische Gesellschaft (*J.f.G.*, Jan. 25).

ELECTRIC LIGHTING.

Editorial. Lamp Rating and Lamp Selection (*Elec. Rev.*, N.Y., Feb. 8).
Fennell, W. Arc Lamps for Outside Shop Lighting (*Elec. Rev.*, Feb. 14).
Pole, J. C. The Cooper Hewitt Quartz Lamp (*Elec. Rev.*, N.Y., Feb. 8).
Cotton Mill Lighting (*Elec. Rev.*, N.Y., Feb. 1).
Church Lighting, (*Elec. Industries*, Dec. 25).
Fortschritte in der Glühlampentechnik (*Z.f.B.*, Jan. 30, Feb. 10).
Village Lighting (*Elec. Rev.*, Jan. 31).
An Edison Electric Safety Lamp (*Elec. World*, Jan. 25).

GAS, OIL, AND ACETYLENE LIGHTING.

Editorial. The Alliance of Gas and Electrical Supplies (*J.G.L.*, Feb. 11, 18).
Himmel, — Ueber Strassenbeleuchtung mit Starklampen (*J.f.G.*, Feb. 8).
Pierce, R. F. Deterioration of Gas-lighting Units in Service (*T.I.E.S.*, December, 1912).
Strache, H. Behaviour of Mantle-Lamp Nipples (*G.W.*, Feb. 8).
Wordingham, C. H. " Our Friend the Enemy " (*J.G.L.*, Feb. 11).
Incandescent Mantles and Lighting Efficiency (*J.G.L.*, Jan. 28).
The New Keith Light (*J.G.L.*, Feb. 18).
The Present Position of the British Gas Lighting Industry (*Am. Gaslight Jour.*, Feb. 10).
Pressgas- oder Bogenlichtbeleuchtung (*Z.f.B.*, Jan. 30).
Automatic Unattended Fog Signals (*Acetylene Lighting and Welding Journal*, Feb).
Acetylenbeleuchtung (*Z.f.B.*, Jan. 30).
Fortschritte auf dem Gebiete der Gaszünder (*Z.f.B.*, Feb. 20).
L'Avenir de la Lumière (*Rev. des Eclairages*, Feb. 15).

CONTRACTIONS USED.

G. W.—*Gas World.*

J. G. L.—*Journal of Gaslighting.*

J. f. G.—*Journal für Gas- und Wasserversorgung.*

T.I.E.S.—*Transactions of the Illuminating Engineering Society* (*U.S.A.*).

Z. f. B.—*Zeitschrift für Beleuchtungswesen.*

The ILLUMINATING ENGINEER
ELECTRICITY · ACETYLENE · OIL · GAS
Edited by LEON · GASTER

THE JOURNAL OF SCIENTIFIC
ILLUMINATION.
OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London, 1909.)

ILLUMINATING ENGINEERING PUBLISHING COMPANY, LTD.
PUBLISHING OFFICES :—ATHENÆUM PRESS 13, BREAM'S BUILDINGS, LONDON. E.C.
Tel. No. 2120 Central.
EDITORIAL OFFICES :—32, VICTORIA STREET, LONDON, S.W.
Tel. No. 5215 Victoria.

EDITORIAL.

The Centenary of Gas Supply.

THIS number is devoted to the special lecture on the history of gas lighting delivered by Mr. W. J. Liberty before the Illuminating Engineering Society on March 11th.

The present year, being the centenary of gas supply and the jubilee year of the Institution of Gas Engineers, the moment is opportune for the lecture. Mr. Liberty has presented a record of events which, besides being interesting at the present moment, will doubtless prove useful for reference in years to come. The latter part of the lecture, dealing mainly with the developments of lamps, burners, and illumination has perhaps the greatest technical interest for our members. But the account of the difficulties and prolonged upward struggles of gas lighting during the early part of last century has also a strong human interest which will grip even those quite outside the gas industry.

We in the present day can probably form only an imperfect conception of the immense difficulties that beset the pioneers of gas lighting. In addition to the opposition of those who feared that trade interests might be threatened, there was the difficulty of convincing even the well-disposed that the undertaking was practicable. We must remember that in those days the idea

that the means of lighting could be conveyed through pipes from a central generating station was so novel as to be almost impossible for the public to grasp. No doubt the slow education of the public to this conception did much to pave the way for electric lighting. People who had become familiar with the conveyance of gas through pipes were the more ready to admit the possibility of transmitting electricity along wires.

But even when prejudice and opposition from without had been overcome the early pioneers were still faced by difficulties from within. The problems of measuring the gas consumed, purification, and prevention of leakage were but slowly solved, and it will be readily understood that the unfavourable impression derived from early failures in this respect only gradually passed away. Again, when the technicalities of gas distribution had to some extent been mastered, there came the financial troubles which for a long time harassed the various companies. The story of the mutual distrust and competition between those engaged in fighting the same battle makes strange reading to-day.

Eventually the period of amalgamation began, and the financial position of the companies improved. It may be believed that the consumer did in the long run benefit from the greater stability of the industry and more perfectly organized service. But the natural results of unrestricted monopoly soon became evident. The profits earned by the companies at this time were out of all proportion to the services given, and the consumers had to go to Parliament to redress their grievances.

But even when the price of gas had been lowered the position of the industry was not healthy. It still suffered from its sense of security, and a period of stagnation set in. It was only the bracing competition of electricity in the eighties that aroused the progressive instinct once more. Since that time both illuminants have developed side by side. Any forward step in the one has called forth a corresponding effort on the part of the other.

It is probable that few people fully appreciate the enormous capital that has gradually been sunk in the gas industry, and the very large number of people who depend upon it for their livelihood —a relation that has been strengthened by the system of co-partnership now adopted by practically all the leading companies. In addition, the complex ramifications of the vast business built up on the disposal of coal-tar products, and the large number of trades that are practically interested in the sale of coal, gas, and coke make the position of the gas industry unassailable.

We, ourselves, believe that there is ample room for both gas and electric lighting. Just in the same way as the candle makers

and manufacturers of oil lamps, who believed their trade to be menaced when gas was introduced, are now making more lamps and candles than they ever did; so, the development of electric lighting, by stimulating the public appetite for improved illumination, has been on the whole actually beneficial to gas.

It is idle to suppose that an industry would not have received this strong support if it had not represented a commodity for which there is a genuine public demand, for heating, lighting, and power. We believe that the tendency in the future will be towards closer co operation between gas and electric interests, and that in times to come the policy of unreasonable competition will seem as singular as the conflicts between the early gas companies appear to us to-day. There are already a large number of municipal authorities owning both gas and electricity supply works, and we see promise of co-operation in other directions. It is therefore clearly desirable to study in a dispassionate manner the legitimate spheres of action of both illuminants, and for the gas and electrical industries to help each other as far as possible, instead of spending their strength in mutual opposition. We venture to hope that the Illuminating Engineering Society will be a great force for good in this direction.

The Gas Industry and Illuminating Engineering.

In the early part of his lecture Mr. Liberty showed how the gas companies were gradually driven by the force of circumstances to improve the quality of gas supplied, and adopt more perfect methods of purification. It must be remembered that gas was widely used for public lighting long before it could be generally used for illuminating interiors. Indeed, even the Royal Society of Arts, always to the front in adopting new methods of lighting, only finally replaced their oil lamps by gas in 1854.

It was natural that attention should next be concentrated on the design of lighting appliances. The history of the development of lamps and burners was sketched in the second section of this lecture, and illustrated by an exhibit showing the gradual development from the first iron burners up to the most up-to-date forms of lamps. It is a big step from the flat flame burner of our boyhood to the high-pressure lamps of to-day. Many of us can remember how dark and dismal night travelling in London used to be in the early eighties. But if we go back to the beginning of the century, when Pall Mall was first illuminated by gas, it becomes difficult to realize how dimly lighted the streets must have been. Some evidence given before the Commission on the Bill of 1909, and referred to in this journal,* gives an idea

* *Illum. Eng.*, vol. iii., 1910, p. 18.

of the approximate light yielded by these early lamps. They are said to have been equal to about eighteen of the old oil Parish lamps they superseded, and probably gave not far from 3–5 c.-p. Contrast this with the modern high-pressure street lamps giving 2,000 or even 4,000 candle-power!

It would indeed be difficult to over-estimate the social value of the development of illumination during the past century. The effect of artificial light being available so much more readily in the evenings has enabled people to turn their leisure to good account and to cultivate their minds; and it is surely more than a coincidence that the development of gas lighting coincided with the increased output of printed matter and the movement for improved popular education. In addition, there are many industries which may be said to owe their existence to the fact of abundant artificial light being obtainable at night.

The improvement in lamps and burners was a natural development following the greater care bestowed on the quality of gas, and during recent years the tendency has become increasingly manifest for the gas companies to take more interest in practical problems of illumination. Their functions no longer stop short of the delivery of the gas, but embrace the problem of the best methods of using it. Maintenance schemes are now becoming general, and it may be predicted that in the course of time the planning of gas-lighting installations and the scientific scheming out of novel and efficient types of units will be much more energetically taken up than at present.

We are now embarking on a fresh stage in the lighting industries during which more attention will be paid to the best methods of making use of light than ever before. Illuminating engineering will prove a greal help alike to the gas and the electrical industry. We therefore take this opportunity of repeating the welcome extended at the meeting to the gas industry to support the illuminating engineering movement. At present the number of representatives of gas lighting in the ranks of the Society is not adequate. We hope that very shortly the industry will be more fitly represented.

Many are the friendships that have been formed between those interested in different methods of lighting, who find in our Society a common meeting ground where they can exchange ideas and learn to respect each others' points of view. The modern tendency, not only in business, but in international relations also, is towards mutual toleration and compromise, and this is the spirit that the Illuminating Engineering Society desires to foster.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

The Centenary of Gas Lighting and its Historical Development.

A MEETING was held in the rooms of the Royal Society of Arts on Tuesday, March 11th, Mr. F. W. GOODENOUGH in the chair.

The minutes of the previous meeting having been taken as read, the names of applicants for membership were announced in the usual way.

The CHAIRMAN then added that on April 15th a joint meeting would be held with the Institutions of Gas and Electrical Engineers and the Institution of Municipal and County Engineers, when Mr. Trotter would present a paper on 'Street Lighting, with special reference to the Standard Specification.' Those desiring to be present, and wishing to have advance copies of the paper, were requested to communicate with the Honorary Secretary.

Continuing, the Chairman said that the meeting that evening was a special one devoted to the gas industry, and they had the pleasure of having present—and he was now going to ask him to take the chair—Mr. Bond, of Southport, Vice-President of the Institution of Gas Engineers. Sir Corbet Woodall, the President of the Institution of Gas Engineers, was unfortunately forbidden by his doctor to take more evening engagements than he was compelled to; in his absence Mr. Bond had very kindly consented to preside.

Mr. J. BOND (Southport) then briefly called upon Mr. Liberty to deliver his lecture, which will be found *in extenso* on pp. 175–230.

The CHAIRMAN, at the close of the lecture, expressed the thanks of the meeting to Mr. Liberty for the very interesting way in which he had dealt with the history of gas lighting, pointing out the various difficulties in connexion with leakage and purification met with in the early stages. He believed that in some of the London streets old wooden mains had actually been unearthed; these, of course, would account for a big loss. At the present time, however, there was practically no loss through leakage from faulty mains. He now called upon Mr. Doig Gibb to second the vote of thanks.

Mr. DOIG GIBB, in seconding the vote of thanks, mentioned that he had recently come into possession of a great many of the pamphlets appertaining to the different gas companies which were in active competition in Edinburgh in the beginning of last century, and had been much amused by a serious proposal that cans of compressed gas should be delivered to the subscribers each morning with the milk. This bore out Mr. Liberty's remarks as to the extraordinary nature of the competition which used to exist in many of the provincial towns. Another interesting feature of this early literature of the Edinburgh gas companies was that many of the pamphlets were signed with the photograph of Sir Walter Scott, the great historical novelist, who, probably some were aware, was chairman of one of the Edinburgh gas companies for a great number of years. It was interesting to observe that the Gas Light and Coke Company, which originally only used 400 tons of coal per annum, now used 2½ millions.

Everybody would agree that the preparation of this discourse had meant

a very considerable amount of research work, and Mr. Liberty had undertaken a gigantic task in condensing into one lecture a history which could profitably occupy a series of lectures.

Mr. F. W. Goodenough, on behalf of the Illuminating Engineering Society, said he would like to add a word or two of joint congratulation and condolence to Mr. Liberty: congratulation upon the success with which he had brought together all the material for a complete history of gas lighting for a hundred years, and condolence in the same direction that Mr. Doig Gibb had mentioned in the very trying task of attempting to select from the wonderful fund of information that he had got together enough—and only enough—to keep within the time at his disposal. They would all look forward to reading the lecture when it appeared in the journal. Mr. Doig Gibb had referred to the 400 tons of coal which the Gas Light and Coke Company started with, and it was rather interesting to know that at the present time the Company used in twelve hours just the same quantity as was used in twelve months when the Company started, and this, he thought, put in rather a striking way the difference between a hundred years ago and to-day.

Mr. Liberty had referred to the advice of King Henry to hang thieves, and this reminded him of the old saying that "every gas lamp was as good as a policeman."

Mr. Leon Gaster congratulated Mr. Liberty on his lecture, and expressed the pleasure that it gave the Society to see so many representatives of the gas industry present. One of the most striking things about the lighting industry of to-day was the increased attention paid to the way in which the illuminant, whether gas or electricity, was used. Light is the cause; illumination the effect. All were interested in the provision of good illumination, and he hoped that many of those present would support the Society in its efforts to solve this problem, and to educate the general public. In conclusion, he expressed special acknowledgment of Mr. Bond's kindness in presiding at the meeting.

Mr. Liberty briefly acknowledged the vote of thanks, adding that he himself was much indebted to the help derived from many quarters, particularly *The Gas World* and *The Journal of Gas-lighting*, and the Gas Light and Coke, South Metropolitan, and Tottenham and Edmonton Gas Companies. He had also to acknowledge the help of those firms who had assisted by the exhibition of lamps and apparatus.

The Chairman, in bringing the proceedings to a close, expressed the pleasure it had given him to preside at a meeting of the Illuminating Engineering Society, which was doing a great deal to help on the cause of good illumination.

New Members of the Society.

The names of the applicants for membership, read out at the previous meeting on February 18th,* have now been formally announced for the second time, and these gentlemen were declared Members of the Illuminating Engineering Society. In addition, the names of the following gentlemen have been duly submitted and approved by the Council, and were read out by the Hon. Secretary at the meeting of the Society on March 11th:—

Ordinary Members.

Blackmore, A.	Electrical Contractor, 5, Montpelier Street, London.
Clevesley, A. J.	Engineer and Expert in Petrol Air-Gas Lighting, 58, Dunedin Road, Leyton, Essex.
Moss, H.	Electrical Contractor, 116, Horton Grange Road, Bradford.
Porter, G.	Edmundson's Electricity Corporation, 20, Tothill Street, Westminster, S.W.
Young, H. T.	Messrs. Troughton & Young, 6, Park Mansions Arcade, Knightsbridge, London, S.W.

* *Illum. Eng.*, Lond., March, 1913, p. 124.

The Centenary of Gas Lighting and Its Historical Development.

By W. J. Liberty,

Inspector of Public Lighting for the City of London.

(Lecture delivered at a meeting of the Illuminating Engineering Society held at the House of the Royal Society of Arts, John Street, Adelphi, London, on Tuesday, March 11th, at 8 P.M.)

Portrait of the lecturer, Mr. W. J. Liberty.

Abstract.

In this lecture Mr. W. J. Liberty sketches in an attractive manner the development of gas lighting from the commencement of the last century up to the present year. He describes the very first attempts to manufacture illuminating gas. The scientists of that day were very sceptical, and there was much opposition. It was only after three years' perseverance that a charter was obtained from King George III. On June 24th, 1812, the first meeting of the Incorporated Gas Light and Coke Company was held, and by 1816 no less than sixteen miles of main were laid in London. Among the early difficulties may be mentioned leakage and imperfect purification. Even after gas had established its position for public lighting it was long before it could be conveniently used for indoor illumination. The room of the Royal Society of Arts (in which this lecture took place) was not so lighted until 1849.

A special tribute was paid by Mr. Liberty to the early work of Murdoch and Clegg, the latter of whom devised the first gas meter.

Gas lighting next entered upon a stage of ruinous competition between the different companies. Finally, in the period 1868-83, amalgamation began. Companies at this time paid substantial dividends and the price of gas was also high—in some cases as much as 6*s.* per 1,000 cubic feet. This favoured position of the gas industry eventually gave rise to a state of inertia and stagnation, and it was only in the early eighties, when the formidable competition of electric lighting made itself felt, that progress was made. The discovery of the incandescent mantle by Welsbach brought about an entirely changed state of things. A great stimulus to the use of gas among the poorer classes was the introduction of the penny-in-the-slot meter.

For a long time lighting was carried out by oil lamps, and it was the duty of each householder to hang such a lamp outside his doorway and keep it lighted for stated periods. In 1736 the Lord Mayor and Commonalty applied for powers to attend to the lighting of London, which thus passed from being a private duty to a public one.

Mr. Liberty then passes on to the early forms of gas burners, ranging from the earliest iron rat-tail burners and the "steatite" burner of 1868 up to the latest types of to-day. Much interesting information is given as to the date at which changes were made in the lighting of various districts in London. There are still to be seen in parts of London the old iron funnels or extinguishers beside the hall door into which torches were plunged and extinguished by parties returning home.

The lecturer also traces the rise of high-pressure gas within the last decade. The Tower Bridge was among the very first lighted by this means. Reference is made to the combined lighting by gas and electricity in Holborn and in the City of London, by which vastly improved illumination had been obtained at a reduced cost. It is now becoming usual to specify the provision in the streets of a certain illumination. The whole question of street lighting is now receiving much more study, and suggestions are being made as to the best means of distributing the light and avoiding glare; all these are matters which are receiving the attention of the Illuminating Engineering Society.

PART I.

A Short History of Gas Lighting.

When approached by the Illuminating Engineering Society to give a Centenary Lecture on this subject, I replied, perhaps unwisely, in the affirmative; had I, however, at that time an idea of the magnitude to which the subject would grow I might have paused ere so replying. Having looked over what I have previously written or said on the subject from an "historical" point of view, I found it necessary to break fresh ground, and trace in addition the evolution of gas in its relation to illumination.

Fig. 1.—Group of scientific celebrities 1800, amongst whom are Murdoch, Watts, and Boulton.
(*From a photograph of a picture in the National Gallery, by kind permission of Mr. Charles Hunt.*)

This year the "Chartered," or Gas Light and Coke Co., are keeping their centenary, the Institution of Gas Engineers their jubilee, the British Commercial Gas Association and the Society of British Gas Industries have recently come into being; surely this is a fitting time to take a backward glance, and briefly scan the years that have passed since the introduction of gas supply; to record some of the struggles of those early days; to trace the success the industry afterwards achieved; and to dwell on some of the benefits it has conferred upon the community.

With this object in view, therefore, I propose to dwell on the enterprise of the industry and the use of gas as an illuminant rather than its discovery. In a hundred years' survey of the gas industry there are many topics equally important as those mentioned, that could be dwelt upon at great length, such as Constructional Work, the Various Forms of Retorts and their Settings, Purification, Bye Products, the Great Aniline Dye Industry, Tar, Pitch, Naphtha, Benzole (or Motor Spirit), Creosote (exported to the Far West for timber preservation), the Various Oils, Ammonia, Sulphates of Ammonia (for the land), the Chemical Side (so ably dealt with recently by Mr. Butterfield),[1] the Domestic and Industrial Use of Gas, Main Laying, and Distribution. Any one of these subjects would easily occupy a whole evening.

Early Stages in Gas Supply.

This year—1913—is not the centenary of the introduction of gas lighting, but is more definitely connected with the hundredth anniversary of the Gas Light and Coke Company, 1812 being the date that the Company received their Royal Charter, hence the "Chartered Company." It would be necessary to go back to 1807, when gas was first introduced as an illuminant in the

1 'Chemistry in Gas Works,' two Lectures by W. J. A. Butterfield delivered at the London University College, December, 1912, and January, 1913.

public streets, or a little earlier, when, at the beginning of the nineteenth century, we find Murdoch contemporary with Watts and Bolton.

Shirley, The Rev. Dean Clayton of Kildare, and Murdoch loom largest in the epoch belonging to the discovery stage, and they go back beyond the centenary. The initiatory period claims Murdoch, Winsor, and Samuel Clegg.

The progress of lighting in London and the provinces is linked with many names—Clegg, Malan, Peckston, Lowe, Alexander Wright, Thomas Livesey, Sir John Thwaites, Alex Angus Croll, F. J. Evans, Thomas Newbigging of Manchester, Charles Hunt of Birmingham, Alfred King, Dr. Letheby, Hartley, Sir George Livesey, Wm. Sugg, George Bray of Leeds, Sir Corbet Woodall, Dr. Carpenter, Mr. H. E. Jones, Prof. Vivian B. Lewes, and others.

No names are better known to the student of gas history in connexion with the Parliamentary era and the early movement for the transfer of gas undertakings to Local Authorities, than those of "Hawksley, Barlow, Hughes, Stevenson, Spice, Penny, and Michael."[2]

The publication of "King's Treatise" (named after its publisher, the late Mr. W. B. King, of the *Journal of Gas Lighting*), on the engineering, chemical, and other departments of the industry, marked an era in the literature of the subject, and may still be ranked as a standard treatise.

Among those connected with the important work of "districting" may be mentioned Mr. Thomas Livesey, Mr. Pridden, and Mr. Hinde, who were the Secretaries of the "Phœnix," the "South Metropolitan," and the "London" Companies respectively; also Mr. Croll, of the Great Central Company.

Early Experiments in London.

July, 1907, well deserves to be termed an epoch-marking period in the history of gas lighting, completing as it does the centenary of the introduction of gas lighting as a practical means of illuminating the streets in the centre of London. True, a little earlier, in the year 1803, Frederick Albert Winsor, a German by birth, lighted the Lyceum Theatre with gas; and on January 28th, 1807, a display on a large scale (judging by the prints published at that time) had been provided by Winsor in Pall Mall, for the benefit of the West-End. While the crowd still lingered and gazed at "the long line, between St. James's Palace and Cockspur Street, that did blaze out in a burst of gas-lamps to the no small wonder of the public." Sir Walter Scott, in writing of Winsor, was saying, "There is a madman proposing to light London with—What do you think?—Why with smoke!" Yet while even Sir Humphry Davy and both the popular and scientific Press were expressing hesitation at the proposal, the City Lighting Authority not only considered, but had installed a practical demonstration of street lighting in their area. In a circular dated July 10th, 1807, the Clerk to the Lighting Commissioners states that: "Having had an offer to try the experiment of lighting the public lamps with gas, the same will be put into execution in Golden Lane and Beech Street, in the Ward of Cripplegate Without, Monday night next, and continued every night until the following Monday (July 15 to 22)." The experiment was so satisfactory that it at once became the permanent illumination.

In 1808 Murdoch presented to the Royal Society his account of the application of gas light, for which he received Count Rumford's Medal. In the year 1810 the indefatigable Winsor, after much opposition and many defeats (being strongly opposed by Murdoch in his endeavour to start the National Light and Heat Company), succeeded in obtaining an Act of Incorporation, entitled the "Gas Light and Coke Company," with a capital of £200,000.

In an old volume published in 1828 by J. Williams, a citizen "of Cornhill by the Exchange," an ardent agitator on gas and water matters, it is stated that the meeting to further the Company and raise the capital was held in the City at the "London Tavern," which was situated in Bishopsgate, a tavern noted for the assembling of

2 'A Hundred Years of Gas Enterprise,' Thomas Newbigging, 1901.

citizens for debating the problems of the day. I will let the narrator speak for himself :—

"At length Mr. Winsor (a Prussian) appeared in London about the year 1800, and gave lectures at the Lyceum Theatre on the theory of lighting with coal gas, on the principle of M. Le Bon, at Paris. For a year or two it was a popular amusement to go to the Lyceum to see the gas ; and after a few years, a public meeting was called at the London Tavern [City] to raise subscriptions to bring this theory of gas into public use. £20,000 was then placed at the disposal of twenty-four gentlemen, as a Committee of Trustees, to ascertain the possibility of lighting the streets with it ; and, if practicable, to apply for an Act to enable the proprietors to light the streets of London. Unforeseen difficulties came forward to oppose this project. No one appeared bold enough to show himself a friend to it. It was the insidious sneer of the wise, and the bold ridicule of the ignorant ; yet after three years' perseverance, an Act of Parliament, and also a Charter from King George III. were obtained for this national undertaking."

Formation of the Gas Light and Coke Co.

On June 24th, 1812, the Incorporated Gas Light and Coke Company held the first meeting at 27, Norfolk Street, Grant being Governor of the Court, whilst Accum appears among the first Directors, described as a "Practical Chymist."

Meanwhile Winsor continued to lecture in his broken English, issuing most extravagant literature and making most extraordinary promises with regard to the new illuminant. Being neither chemist nor mechanic, he gave his free imagination full play, and nearly spoiled gas lighting with kindness ; but the discovery was too genuine to be easily killed. Here is a sample of his literature : "As to illuminations, they may be carried on to the utmost extent of beauty and variegated fancy by this docile flame, which will play in all forms, submit to instant changes, ascend in showers from the trees and walls, arise from the water, and even in the same pipe with a playing fountain. The constant varying of flames in rooms and gardens, between pyramids, festoons, garlands, roses, palms, palm twigs, suns, stars, moons, torches and flambeaux, cherish the soul and create good humour by uniting convenience, utility, and pleasure." His imagination ran further riot when dealing with the financial aspect of the question, as he dwelt on the millions that the new Act would save and the enormous profits that were to fill the pockets of its promoters.

"What a dreamer of dreams was this man ! and with what reckless daring," says Newbigging,[3] "did he relate his theme to the often unsympathetic audience of his day ! He even asserted that, besides its illuminating properties, the explosive force of gas, when mixed with air, might be utilized for obtaining prime motion, and that the heat of the flame might be employed to advantage in cooking food and warming apartments. Who could credit such nonsense. What a visionary he was ! Perhaps, after all he was only farseeing."[4] Beneath it all there was his remarkable "courage and persistency, his foresight as to the uses of gas," his strenuous efforts to enthuse the minds of others, hampered by his inability to clearly express himself in our language.

In 1813 the directors of the Chartered Company voted Winsor an annuity of £600 per annum, he already receiving one per cent on the net profits of the undertaking. (For certain reasons the annuity was suspended in 1815.) He became a director of the Company, and frequently took the chair. Later he withdrew to Paris, where he unsuccessfully endeavoured to start a gas-lighting campaign : a company was formed, but ended in bankruptcy. After enjoying an annuity from his old Company in London since 1820, he died in Paris in 1830, at the age of 67.

---

3 'A Hundred Years of Gas Enterprise,' Newbigging, 1901, folio 19.

4 Newbigging, *loc. cit.*, 1901, pp. 19-20.

1807

Admission for Two Friends from Walsh Porter Esq

N. B. On Mondays, Wednesdays, Thursdays, and Fridays, at 6 o'clock.

Mr. Winsor, the Patentee, most respectfully invites all Members of Parliament to a constant free Admission, to enable them to speak to facts, whenever this important National concern, is brought before them as Legislators.

NATIONAL

Light and Heat Company,

No. 97, PALL MALL,

TO BE ESTABLISHED WITH

A Million of Capital

In 20,000 SHARES,

F. A. Winsor

Under the sanction of an Act of Parliament.

THE Share receipts of this Lucrative Concern are now delivering at this Office. at the Banks of Messrs. DEVAYNES and Co. 39, *Pall Mall*, and Sir Matthew BLOXAM and Co. 27, *Gracechurch Street*, where Plans and estimate Tables may be had gratis, as also at LLOYD's and BATSON's *Coffee-houses*. Two Houses are nearly finished for standards of a general introduction of those cheap and beautiful Patent Lights. Official Experiments proved one chaldron of Coal to contain £23 2*s*. in value; which gives above 242 Millions for the yearly consumption of the Realm The estimate Savings are only rated at £114,845,294, all costs of carbonising &c. deducted; and if the *Company* only realize 1-10*th* of this reduced Sum, each £5. deposit will secure to the Subscribers £570 per annum. Wonderful as this may appear, the Estimates and Experiments will stand the test of the best calculators and Chemists. The whole is detailed in Mr. Winsor's Pamphlet on the *National Light and Heat Company*

Many respectable Subscribers, seeing my experiments, have applied for an increase of Shares on the following scale of Deposits, which I cheerfully submit to the Public as the most flattering testimony of the encouragement of my plan.

Five Shares, to pay £3. deposit each, and have 1 vote.
Fifteen Shares, to pay £2 10s. deposit each, and have 2 votes.
Thirty Shares, to pay £2. deposit each; and have 3 votes
Sixty Shares, to pay, £1. deposit each, and have 4 votes.
One hundred Shares and upwards, 10s. each, and have 5 votes.

Beyond which no Vote allowable.—With written engagement for the remainder of the £5. deposit. as soon as the Company is formed,

*** This Plan is now rendered so *generally Beneficial*, that every Person commanding £5. deposit only, may secure a handsome yearly Income for Life, and Provision for his descendants, which is the more certain, as the example of the *New River Shares*, having risen from £100 to £13000. and upwards, is now before our eyes; though they produce only a local convenience—whereas this COMPANY gains several valuable products, three times in 24 hours.

FIG. 1A.—Handbill issued by Winsor, 1807.
(*From the original kindly lent by Mr. Charles Hunt.*)

His enterprise was looked upon as visionary, though the Royal Charter was granted. Yet the privileges of the Charter were neither liberal nor encouraging the powers granted being extremely moderate and the restrictions many. The Gas Light and Coke Company thus established commenced operations on a site now occupied by the Civil Service Institution, in Cannon Row, Westminster.

FIG. 2.—Murdoch's house at Redruth as seen to-day.
(*From Mr. Chas. Hunt's 'History of Introduction of Gas Lighting.'*)

"Murdoch was a different type of man from Winsor, shrewd, practical, persevering, working away and saying nothing, or but little (a typical Scotsman), he laid the foundations of an Art —dealing with the appliances and apparatus for evolving the product both economically and efficiently."[5]

Murdoch, seconded by Winsor (though opposed to him at times), and backed by Clegg, turned failure into success. As Mr. Ferranti recently pointed out in his James Watts Centenary Lecture,[6] it has been the same more or less with all early inventions, owing to the temporary makeshifts and the indifference that surrounds the British inventor. "James Watt's efforts were looked upon with an apathy and lack of faith that caused him the deepest despondency. Had it not been for good Matthew Boulton and his stout heart Watt's work could never have been accomplished. Even as it was, the two men lived on the edge of a cliff; they peered down at bankruptcy all day long."[7]

Murdoch had achieved fame by illuminating the Soho Works, Birmingham, of Messrs. Boulton & Watts, upon the Celebration of the Peace of Amiens. Clegg came from this Birmingham works. Mr. Charles Hunt, of Birmingham, in his work,[8] quotes from *The Mechanic's Magazine* (1834), vol. xxii. pp. 470–2, that "Clegg first had his attention directed to the practicability of distilling gas from coal when assisting to illuminate the Soho manufactory."

Mr. Newbigging, speaking of him, says his "was the ablest mind that applied itself to the subject. Trained as an engineer and with some knowledge of Chemistry—resourceful and energetic—these acquirements and inherent qualities enabled him to grapple with the early difficulties."

Other pioneers soon came into the field—Northern, of Leeds, Pemberton, of Birmingham, Dr. Henry, of Manchester, and Accum, chemist, historian, and author of an important work on Gas Manufacture.[9]

As an evidence of the small beginnings from which the "Chartered" Company sprang, it may be mentioned that the area of the Company's territory in 1812 was but 10 acres; while to-day the area is one of over 120 square miles in extent. The Company's capital of £200,000 has risen to

5 Newbigging, 'One Hundred Years of Gas Enterprise,' 1901, p. 21.

6 See Mr. S. Z. de Ferranti's James Watts Lecture, 1913.

7 *Electrical Times*, vol. xliii., 1913, No. 1,110, p. 82.

8 'The History of the Introduction of Gas Lighting,' 1907, p. 65 (Charles Hunt).

9 'A Practical Treatise on Gas Light,' Frederick Accum, 1815, four editions.

about £30,000,000; and while they started with a coal carbonization at the rate of 4,000 tons per annum, they have now an equivalent of 2¼ million tons of coal carbonized annually. The rates paid by the company at the start was £150 10*s.* 4*d.* During the present year of grace it is a trifle over £300,000; while 1*d.* reduction in the price of gas (small as it may appear), on the 25,484,985,000 cubic feet annually sold, would represent a sum of about £100,000.

Early Difficulties and Obstacles.

During the first decade of the Company's existence progress was very difficult, owing to the want of a competent engineering head. Brewers' vats were purchased for gas holders.[10] The absence of any dividend until 1817, the want of a means of measuring the amount of gas sold to the consumers, and the abuse by the consumers of the then system of charge—"gas rental" per burner—and the consequent ill-feeling generated between buyer and seller as to the amount used, caused these years to be very lean indeed. In 1816 there were, however, 16 miles of main in London.

About this time the avenues to the House of Lords and House of Commons, the residence and offices of the Speaker, the Mansion House, and many important places, adopted gas. To illustrate the rapidity of main-laying, the gas historian of that time states that the Liberty of Norton Folgate, as far as Bishopsgate, was lighted with gas from the Chartered Company's station at Norton Folgate; and pipes were laid from that station as far west as Cheapside, and all streets north of that thoroughfare. In the West-End, the mains for supplying the streets and houses by the Gas Light and Coke Company extended northwards through the most eligible parts from their establishment in Peter Street, Westminster, along the line from Pall Mall to Temple Bar, completely surrounding the area of St. Martin's-in-the-Fields. "Main pipes" were also laid in the Haymarket, Coventry Street, Long Acre, St. Martin's Lane, and the parishes of St. James and St. Ann.[11] In the East-End of the Metropolis, mains extended from Cornhill to St. Paul's, Wood Street, Fore Street, &c. Consent had also been given to the Incorporated Gas Light Company for laying pipes in the parishes of St. Paul, Covent Garden, St. Mary-le-Strand, St. Clement Danes, St. George, Bloomsbury, St. Giles-in-the-Fields, St. Andrew, Holborn above the Bars, part of St. Mary-le-Bourne, and the whole of the City and suburbs of Westminster.

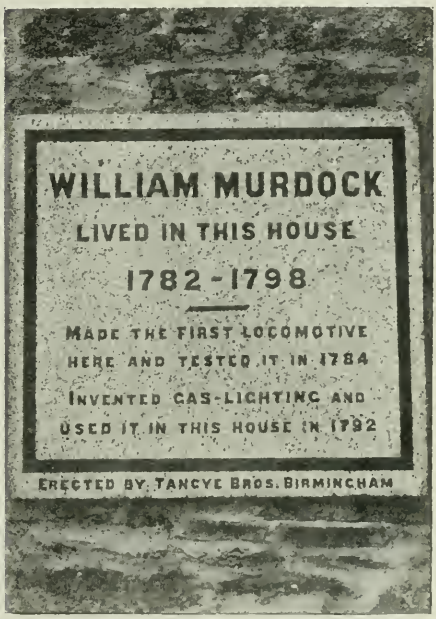


FIG. 3. Tablet placed on Murdoch's House at Redruth by Messrs. Tangye.

From Mr. Charles Hunt's 'History of the Introduction of Gas Lighting,' 1907.

Still further East the same Company were engaged laying their pipes in the principal parts of Whitechapel, Spitalfields, and St. Luke's. One part of the City of London, from Temple Bar to the west end of Cheapside, from Newgate Street to Holborn Bars, together with the neighbouring streets, was also provided with pipes laid down by another Gas Light Association, who had opened a new establishment in Water Lane by Fleet Street, but

10 See The Gas Light & Coke Company, 1812-1912,' London, 1912, p. 31.

11 Newbigging, 'History,' p. 24.

were unconnected with the Chartered Company. A third Company was projected in Southwark, and a fourth in the East of London, "creating a rivalry of interest—that laudable competition which always proves beneficial to the public at large, and which cannot fail to accelerate the progress of the new art of procuring light." If Accum, the writer of these remarks, could have foreseen the chaos and ruin, as well as the set-back to the gas industry, that followed this wasteful competition, he would have considered before using this sentence. Clegg, under whose direction the new system of lighting was being principally carried out, speaking in 1816 of the progress made with the work, said that the main pipes of his Company alone amounted to nearly 15 miles; while it is interesting to learn that one church in the Metropolis had been illuminated with gas light for upwards of two years, "the lights employed in this edifice being equal to 360 tallow candles, eight to the pound."

"Enough, therefore," says the early writer, "has been done to prove the possibility of lighting house and street with gas, which would have been regarded twenty years ago as an extravagant paradox. From the distinguishing forms which the flame is capable of assuming, no light is better calculated for signal lights. If every lighthouse around this island were possessed of a gas-light furnace, one-half of the enormous expense of the present lighting would furnish a much more brilliant light. Another application of gas would be the lighting of barracks, arsenals, &c.; the annual expense of lighting the barracks of Great Britain being about £50,000, a small part of which, on the new plan, would supply a much purer and safe light."

An endeavour was next made to move the public mind, by dismal forebodings of the Greenland trade and the loss of the nursery of British seamen. But even on the extreme supposition that the gas industry was going to put an end to the Greenland fisheries altogether, "Was there," says Accum, "much to regret in it? Why fit out vessels to navigate the Polar Seas for oil, if we can extract a superior article for procuring light at a cheaper rate from the produce of our own soil? The fisheries will find ample encouragement; and the consequence of the lighting of our streets with gas can prove injurious only to our Continental friends, one of whose staple commodities—tallow—we shall then have less occasion to purchase." Yet, so strong was the opposition, that Lewis Thompson, in a paper on 'Coal Gas, and Its Application Considered for the Purpose of Generating Light and Heat,' written in the late fifties, said: "It has long been remarked as a matter of surprise by intelligent foreigners that in a country like Great Britain, where the Arts have attained an unprecedented development, there should be one incessant struggle, one prolonged fight, betwixt ignorant prejudice on the one hand and practical knowledge on the other—in fact, betwixt darkness and light." Thus the early opposition to gas lighting was nothing more than the common clamour always set up against every new means of lightening labour.

Illumination by gas was now making headway; but it was not to be expected that its extension to the dwelling-houses of every town and village should take place at once. Prejudice had to be eradicated, and established habits altered — which was a work that nothing but time could effect. Other circumstances besides prejudice were unfavourable to the new invention — ignorance, vested interests, jealousy, malice, such as so often obstruct the progress of improvement and prevent plans coming to fruition for the public good.

Nevertheless, gas lighting was destined not only to alter domestic habits, but to give a new direction to part of the skill and capital of the country, as well as to increase the output of work, alter the industrial development and wage-earning capacity of the people. The effect of increased wages and comforts brought about by the lengthening of the day had its effect on the reading capacity of the community, for men had no longer

to pore over their books by the aid of a "spluttering rushlight" or a "tallow dip." With better reading facilities came the desire for a more liberal education. New industries came into being, and a stimulus was given to scientific research.

It was some time before the idea of using gas for indoor lighting gained ground. As late as 1815 it was held to be conclusive that the lighting of a parish by street lamps only, without lighting shops and houses, could not be accomplished with economy.

Indeed, it was not until 1849 that this House of the Royal Society of Arts was lighted by gas, and in 1854 the old oil-lamps were removed.

The First Gas Meter.

A great difficulty was the absence of any method of measuring gas. Clegg, however, now came forward with a remarkable invention to meet the case. He had previously, with a view to allaying any alarm on the part of the public, invented a self-extinguishing gas-tap, so constructed that the gas could not flow to the burner when the flame became extinguished; for if the flame was blown out, and the cock left open, the valve automatically shut. This action depended upon the expansibility of a metallic rod heated by the flame of the lamp, and its contraction when the flame was out. His later invention was, however, more wonderful, and is with us to-day; it was called "Clegg's self-acting gauge"—a machine which "measured and registered, in the absence of the observer, the quantity of gas delivered by any pipe connected with the gas-main." The machine occupied a space of about 2 ft. by 1 ft.; and "if put up in a room, house, or other place where gas was burnt, it would, at any time, by mere inspection, give an account of the quantity of gas consumed." This is a description of the first gas-meter; for at that time consumers paid for their gas by rent, at so much per light—by which we have the terms "gas rent" and "rental department." Clegg's gas-meter was further described as for "checking the conduct of workmen on the works, and enabling the manufacturer of coal gas to ensure himself of obtaining at all times the greatest possible produce from his establishment—a measure by which he can deal out the gas in whatever quantities they may require it." In those early days advantage was taken by the unscrupulous to get more than they paid for from the gas manufacturers; for we find it on record that "every person must have noticed how shamefully many disregarded the terms on which they have contracted for a supply of gas—some by means of the excessive flame they keep up, and others by suffering the lights to burn hours beyond the time." In places where gas was supplied on contract to pay for burning a limited time, by means of certain sized burners, "the seller was always in a degree, and in some cases wholly, dependent on the care and honesty of the purchaser." On the introduction of the Clegg gauge equal justice was done to both the consumer and the seller; and, to use the words of Accum, "the waste being transferred to those who occasioned it, the price of gas was reduced to an equitable and correct measure of value."

The benefits had a wider range, for not only was full value secured to the maker for the whole of the gas manufactured, but it became a more marketable article. In the system of charging by the year, half year, or quarter, many who were only in want of gas occasionally, or whose demand was irregular or uncertain—such as the proprietors of theatres—were debarred from availing themselves of it, except at an expense disproportionate to the amount consumed.

Eighteen hundred and seventeen saw Clegg's retirement from the Chartered Company, when he started many gas-works in various parts of the country.

"John Malam, who was contemporary with Clegg, was also endowed with large inventive powers, which extended to almost all the apparatus of gas-works. His centre-valve and attachment of four purifiers are largely in use to this present day. He greatly

improved the wet meter by adding to it the hollow cover and spout."[12]

At this time (1816) it was laid down as a rule that no private individual resident in London whose annual expense for light did not exceed £60 should attempt to light his premises for the sake of economy with coal gas by means of his own apparatus.

In 1819, the extraordinary rapid progress which coal gas had made in the United Kingdom was, we are informed, "without a parallel in the useful Arts."

Stages in Gas Supply.

At this stage it may be well to summarize the chief stages through which gas-lighting has passed in the metropolis.

The various periods might be divided historically as follows :—

1810. "Gas rental" charged, competition.
1823 to 1848. Agreed areas, "Congreve compact" of 1823.
1848 to 1860. Competition.
1860 to 1868. Districting.
1868 to 1883. Amalgamations.
1883 to 1907. Statutory monopoly. (No inside competition.)
1894. From this date meter-rents were waived by the Gas Light and Coke Co., who, however, reimposed them at Midsummer, 1907. They equalled ¾*d.* per 1,000 cubic feet.
1890 to 1912. Electrical competition.

In these early days it was expected that the then Chancellor of the Exchequer would be aggressive enough to levy a tax on the "new lights"; for it was remarked that "in proportion as gas-lights are more or less generally adopted in all towns of the country, the consumption of oil and tallow will be diminished, and the income on those articles will become less productive."

The definition given to mains at this date is not uninteresting—*i.e.*, "Cast-iron pipes, from 2 inches in diameter and upwards, placed underground for conveying gas into smaller branch-pipes, but in a more extended sense." The term is applied to every pipe from which "smaller ramifications or branch-pipes proceed." Again : "All mains destined to convey coal gas should be proved by being submitted to the trial of sustaining a column of water 300 feet high."

It is also curious to note the instructions given to the workmen in laying supplies : "Pewter, tin, lead, or other pipes capable of being melted by a gas-flame should never be employed through the interior of a house, because of the ease with which such pipes might be perforated, and the serious consequences that would ensue if the gas issuing from the aperture were lighted." Copper pipes, being cheaper in those days than iron, were largely used by the several companies ; the objection to corrosion by stopping, which on the introduction of gas was complained of in many places, no longer existed, it being pronounced that pure coal gas produced no action on the copper tubes. Such copper tubes laid in London more than ten years previously were found to be in a state of perfect preservation.

Here are Clegg's 'Directions to Workmen' : 'How to stop a Leak in a Gas-Holder.'—"Dip a piece of cloth about the size of a shilling into some melted pitch tempered with bees wax and tar, apply the cloth whilst hot to the place of the leak with the end of your finger, rubbing it till it is quite cold."[13] So much for the description of the work and methods of the pioneer gas companies and their energetic officers, particularly Clegg, who stood head and shoulders above his compeers at that date. George Lowe followed Clegg on the Chartered Company, being especially identified with the Brick Lane and Curtain Road stations.

A Great Boom.

When the obstacles and prejudices were overcome, and large amounts had been spent on experimental work, a great boom took place. Between the years 1814 and 1819 rival companies arose, especially in the Metropolis. The Phœnix or South London Company had their Act in 1816 ; the City of London Company in 1817 ; while the Imperial Company had commenced by 1820. In 1823 the Ratcliffe Company, and in 1829 the Independent Gas Light and Coke Company commenced operations. The City Gas Company and the Chartered Gas Com-

12 Newbigging's 'History,' 1901, p. 26.

13 Newbigging's 'History,' 1901, p. 32.

pany were permitted under a contract with the authorities to lay down their pipes, with a distinct written agreement that, at the expiration of a given time, the City should be entitled at their own pleasure to purchase them by valuation. The two Companies, however, partitioned the City between them under a secret agreement known as the "Congreve Compact,"[14] and thus established a practical monopoly.

In 1823, when London north of the Thames was being supplied by four Companies, oil gas began to attract a large amount of attention; and an attempt was made to start the London and Westminster Oil-Gas Company, to the alarm of the coal-gas industry, who opposed and petitioned against the proposal in Parliament. In 1824 Michael Faraday gave evidence in favour of the Bill; and eventually, on a report of the Inspector of Gas-Works (Sir William Congreve), investigation was made by a House of Commons Committee, to the undoing of the oil-gas project. The opposition of the gas companies to the measure cost them some £30,000, though several witnesses of the Oil-Gas Company, who had had charge of oil-gas works, admitted a loss on them without the employment of coal gas as an adjunct. In spite of this, and in the face of warnings which in a few years were verified, Bristol was being lighted by oil gas in 1823 under a Special Act.

English Capital abroad.

In 1825 the Imperial Continental and the European Gas Companies were commenced, mainly through the instrumentality of Sir William Congreve, who was Home Office Inspector of Gas Works in the Metropolis.

These Companies, with the "Bombay," "Imperial Ottoman," and Colonial Companies sent the branches of the industry all over the world with British capital, the administration being kept in this country. The fact that parts of Germany, France, Holland, Italy, Denmark, and South American cities, are still (and up to quite recently Vienna, the Austrian capital, was) lighted by British gas companies is proof of the ramifications of the industry. These and many other British-owned companies still exist in all quarters of the globe. The engineers-in-charge (many of them) are from over the Border—*i.e.*, "Wandering Scots"—for instance, Mr. W. S. MacGregor, who has kept the lighting of Constantinople going during these last three months, in spite of the war.

In 1825 most large cities, and from 1845 to 1850 small villages, were lighted by gas.

Ruinous Rivalry.

Following shortly after this came one of the most remarkable periods in the gas industry, when a severe rivalry set in among the various companies. Many of the concerns paid not a farthing in dividends, while others were almost ruined. But this did not prevent the multiplication of undertakings. For instance, in the Metropolis the Imperial Gas Company never paid a farthing from the time of its inception; and similar remarks apply to the City of London and Phœnix Companies. Only the Chartered Company paid a dividend; but, in spite of this, the South Metropolitan Company was launched in 1833, for the purpose of supplying cannel gas, and was incorporated in 1843. So precarious was its early existence, that it was seven years before the unfortunate shareholders received any profits.

Continuing, the Equitable and the London Gas Companies were launched to oppose companies already in the field—with fatal results, as for nearly twenty years they both failed to earn a dividend. The London Company, which was situated partly north and partly south of the Thames—in the Strand and Lambeth respectively—was destined to play an important part in the question of differential prices for gas in London. The Company was established in 1830, and incorporated by Act of Parliament in 1843. The mains were laid across the river, the works being at Vauxhall. Later a move was made to new works at Nine Elms. So happily were they placed that, shortly after this, their troubles ceased, and 10 per cent was paid on

14 Sir William Congreve's arrangement of "agreed areas."

the original shares. The Commercial Gas Company, for supplying the east of the Metropolis, was incorporated in 1847.

At this date the "Gas-Works Clauses Act" was passed, for the purpose of consolidating in one Act "certain provisions usually contained in Acts authorizing the construction of gas-works for supplying towns with gas."

Purification Troubles.

In the summer of 1842 a Committee was formed to investigate the impurities of gas, and the injuries done by the products of burnt gas. The services of Profs. Faraday and Brande, Mr. Aikin, Mr. Brown, and Dr. Prout were enlisted. Without going into the details of their report, it is necessary to say that the experiments were made from investigations of the water used at the Athenæum Club, which water, when evaporated, showed the presence of free sulphuric acid.[15]

In 1854 Dr. Henry Letheby, M.B., Medical Officer for Health for the City of London, presented a long report to the authorities on 'Coal Gas supplied to London, with Examples of Injury done to Books, &c., by the Products of Combustion.' The companies particularly concerned were the Great Central, which supplied the whole of the City; the Chartered, of Brick Lane and Curtain Road; the City Company, which supplied the south of the City; the Commercial Company; and the Company which sent cannel gas to *The Times* office and the General Post Office. Dr. Letheby, who was an authority on photometry, likewise went into the question of illuminating power.

One point to which the Doctor directed attention was the pressure. "This," says he, "is of importance, because, when the pressure is low, the street lights, and even the lights of our houses, are insufficient for the purposes required." The writer did not think that gas should ever be delivered at less than an inch of water pressure.[16]

Specimens of the "soil of the Metropolis infected by tar" and examples of injury done to copper and brass fittings by ammonia accompanied the report. Specimens of products collected from the burning of gas through a Leslie burner, and samples of water from the Athenæum Club House were shown. Specimens were also furnished by "Mr. Faraday, of Wardour Street," and the Librarian of the Athenæum. Mr. Thornhill, of the Literary and Philosophical Society of Newcastle-on-Tyne, stated that where they had fitted up four ventilators over the chandeliers in the room, "As much as half-a-gallon of water is collected of a night from the gas burnt there—this water being so corrosive from the presence of sulphuric acid, that it attacks all the metal fittings with which it comes into contact." At other places also the books were stated to have suffered severely.

Dr. Letheby says: "Within the last day or two, I have visited the library of the Royal College of Surgeons, in Lincoln's Inn Fields; and though gas is not regularly burnt therein, yet it is surprising to see how much mischief has been done to the bindings of the books by the products of gas consumption. I should think that in the gallery of the Institution there are hundreds, if not thousands, of books, the backs of which are completely rotten....It may be asked whether I can suggest any remedy for the evil. I reply that the remedy is threefold: (1) In respect of the manufacture of gas. (2) As regards its purification. (3) In a more perfect system of ventilation." Dr. Letheby recommended that all gas should be burnt outside the room or shop, whenever practicable; and when this was not so, the products of combustion should be conveyed away as speedily as possible. They ought not, he added, to be allowed to escape into the room at all. "I am sure," says the learned chemist in conclusion, "that many elegant arrangements may be suggested for this purpose."

About this time a very voluminous

15 'Report on Coal Gas,' Henry Letheby, M.B. London, 1854.

16 'Report on Coal Gas,' Henry Letheby, M.B. London, 1854, to the City Commissioners of Sewers.

report[17] on the Nature of Coal Gas was written by Lewis Thompson, Esq., M.R.C.S. (Consulting Chemist). The report is undated; it is twenty-two pages in length. After dealing with the early history of gas lighting, he treats of the chemical properties of gas, and the report contains this gem: "A tradesman hitherto content with an amount of light equal, perhaps, to sixteen sperm candles, suddenly becomes disgusted with the expense, the annoyance, and the uncertainty of his oil lamps; he accordingly sends for a gas fitter, and knowing nothing about the light he has hitherto employed, orders gas to be laid on at about the same rate per quarter. The result is, that instead of a sixteen candle illumination he has probably reversed the figures and got sixty-one. He is, however, delighted with the change, and would never think of going back to the filthy oil." Another piece: "It is quite notorious that workmen constantly employed about gas works enjoy excellent health and attain to an average old age, proving (we are told) that they are 'used to it,' or that, like Macduff, they bear 'a charmed life.'" He adds that "for some temporary purposes, gas at the present London price is cheaper than coal as a fuel." I put the date of this treatise at about 1856, and the price of gas at 4*s*. per 1,000 ft. It is full of tables and data, including a comparative table based on thirty-six experiments of the "time employed" and the cost of wood and coal for fires as against gas fires.

The statements of Dr. Letheby were not allowed to go unchallenged; for a closely printed pamphlet was issued by the Directors of the Chartered Company, they having commissioned two eminent chemists—Dr. Leeson and Mr. R. Warmington, who were appointed by the Directors to report upon the production of oil of vitriol from coal gas "for the satisfaction of the numerous consumers of gas supplied by that Company," and who reported upon "certain inaccuracies" and "exaggerated expressions," which were calculated greatly to mislead and alarm the public—however manifest it might be to the few scientifically acquainted with the subject that so large a quantity of "oil of vitriol," or "vitriolic acid," could not possibly result from the ordinary combustion of coal gas. They believed that the "oil of vitriol" had been manufactured from gas, not produced by the ordinary method of consumption, but by a process adopted for these experiments. They added: "We might, indeed, suggest such a multitude of contaminating influences in this great Metropolis, that even Dr. Letheby's fearful tale would sink into utter insignificance."

In the month of October, 1854, and in February, 1855, Mr. John Simon, writing from Upper Grosvenor Street, went very fully into the complaints of nuisance from the London Gas Works. He dealt with the whole process of purification as then carried out by the gas companies, and particularly with the "blue billy," the discharge of which into the Thames was regarded in the light of a common nuisance. In the City Gas Works, it appears, wet-lime purifiers were in use. The gas "bubbled through great churning tubs of milk of lime, leaving in them its sulphuretted hydrogen, combined into sulphuret of calcium." These, being of no commercial value, were, at certain states of the tide, discharged at night into the middle of the river. The Company, however, in consequence of legal proceedings, pledged themselves to an abatement of the nuisance, and completed a system of dry-lime purification; and this giving a cartable refuse, they no longer polluted the river.

Early in 1860 Dr. Letheby, reporting on experiments on the illuminating power and chemical quality of the gas supplied during the preceding eight years, said: "Instead of resisting decay for more than a century, when brought into contact with the black soil of the Metropolitan streets, saturated with gas, the pipes rapidly

17 'The Nature and Chemical properties of Coal Gas considered with its Economical and Sanitary application for generating Light and Heat,' by Lewis Thompson, M.R.C.S., &c.

decayed, and were rotten in about ten years."

Dr. Letheby stated that the amount of gas escaping into the earth in the Metropolis was no less than 386,000,000 cubic feet per annum. Mr. Spencer calculated it as twice this quantity, and put the total loss at 9 per cent of all the gas distributed; whereas Mr. Wright put it at 5 per cent. According to Mr. Spencer, in round figures, about 630,000,000 cubic feet of gas was annually absorbed into the street earth of the Metropolis, which, it was stated, "darkens the soil, and makes it so offensive that the emanations from it can hardly be endured, renders the basement rooms of houses uninhabitable from the poisonous action of the gas, and even dangerous from explosions, and taints the water with filthy odour." At the rate of 1s. 6*d.* per 1,000 cubic feet, the then cost price of gas, "the loss is more than £47,000 per annum." The remedy for this mischief was given as twofold: (1) To supply gas freer from ammonia and sulphur compounds; (2) the use of tighter joints. Already in some of the large towns of England (as in Liverpool, Manchester, and Leeds) the latter remedy had been applied; the ends of the pipes being turned and bored, and fitted into each other by grinding "like a stopper into a bottle."

This last statement is interesting in view of the paper by Mr. W. G. Head, of the South Metropolitan Gas Co., on 'Main Laying' and the "turned and bored joints" of that Company.

At this time (1854) Dr. Christison of the University of Edinburgh, "the well-known author of our best English treatise on poisons," says "that the gas in Edinburgh kills all the plants in the rooms of that City."

A valuable work on Purification, &c., was published in 1867 by the Rev. Dr. Bowditch, remarkable "not only from the fact that the author was the incumbent of St. Andrew's, Wakefield, but also by reason of its originality and power, and its lucidity."

In July, 1864, a closely printed and interesting pamphlet, signed by Thomas Greaves Barlow (the first publisher of the "*Journal*" *of Gaslighting*, then issued quarterly), addressed to the Directors of the Chartered, City of London, and Great Central Companies, dealt exhaustively with the 'Sulphur Compounds present in the Companies' Gas.'

In the same year Dr. Letheby gave his opinion on the reports of Messrs. Barlow and Ellissen, condensing and tabulating them; mention being made of the experiments of Mr. Bowditch, Dr. Angus Smith, and Mr. Hawksley's communication to *The Journal of Gaslighting*.

In 1848 a report was presented to the London authorities by Mr. Charles Pearson, the City Solicitor, and published in all the newspapers, wherein he demonstrated that the price of gas (then 6s.) ought to be governed by the cost of distribution, rather than by the cost of production.

Competition Within.

Competition was now universal, four or five companies supplying one district. On the south side of the river four companies were supplying Walworth Road, each having a main on both sides of the street—giving eight mains for one thoroughfare. This competition was disastrous; for the companies rarely paid anything like full dividends, and the provision of the 1847 Act was that when full dividends were paid (viz., 10 per cent), a reserve fund of one-tenth of the capital should be accumulated. After that any further surplus was to go in reduction of price. The Act allowed companies to make up their dividend deficiencies of earlier years; and thus full dividends were practically assured by the Legislature. The price of gas was not reduced; nor was it likely to be under such conditions. During 1847 the price was about 6s. 6*d.* per 1,000 cubic feet; and the South Metropolitan Company paid 6 per cent. Most of the other companies paid less—with the exception of the Imperial Company, who were in the happy position of paying 10 per cent.

The consumers were the only ones who reaped any apparent benefit, and this often of an unscrupulous kind, by obtaining their gas for years without

any payment whatever. When the supply was disconnected by one company for non-payment, a nominal deposit would induce a rival company to lay on a supply; and often three services were in the premises at one time. Dishonest consumers could thus take advantage of the secrecy observed by the rival companies to obtain their light free. Concessions of every kind were made to consumers to obtain their patronage, even to the extent of allowing one or more lights to be supplied free of charge. The company would alter fittings gratuitously; while gas would be sometimes supplied at one-third of the sale price. District inspectors had full powers and a free hand (including a commission) to get customers the best way they could—not new customers, it may be here mentioned, but "turnovers" from the other companies. Ready cash changed hands in these transactions. A customer obtained, a meter would be left. A week or two later another company would undertake to supply the customer by contract, with the addition of two or three free lights. Then as the mains of the three companies were side by side in the road, it was not an unusual occurrence to find that a company was drawing payment for gas taken from an opposition company's main.

I recently heard a very old servant of the Gas Light and Coke Company speaking of this, say, "that when a gas fitter went into a basement to connect up a supply he found three service pipes, the "Chartered," the "Great Central," and the "City of London Companies," and that with a view of finding his own company's pipe, he would remove the caps and smell the gas, as each company's gas had a distinct odour in those days." Be this so or not, the difficulty was there, though I prefer to take Mr. Thomas Newbigging's version on the subject, *i.e.*: "An ingenious device was adopted for discovering connections of this kind; holes having been drilled in the respective mains, a ferule with a flexible tube was inserted, the other end of the tube being drawn on to the nozzle of a portable bellows. When this latter was actuated, a pulsation of the contained gas was set up, and this, extending to the lights in the neighbouring tenements, revealed the source of supply."

But this was not the only source of loss to a company; for, in addition—in consequence of the hurried manner in which the mains were often laid, and continual changing of service-pipes—considerable escapes were always taking place, swelling the total of unaccounted-for gas. The difficulty was to bring to book the offending company, as the officers threw the responsibility upon their rivals; and in the event of a leakage being discovered on the mains of one company it was not unusual to attribute it to wilful damage on the part of a rival's workmen. In fact, the spirit of competition reached the point of personal animosity among the directors and officers of the various undertakings. Explosions were the order of the day; and each company made the most of its rival's troubles.

In spite of much ridicule and opposition the Great Central Gas Company was formed by Mr. Charles Pearson and Mr. Alexander Angus Croll, who afterwards became Sheriff. The Company started with the promise to supply gas at 4*s*. (and had a clause in their Act to this effect), to be reduced to 3*s*. 6*d*. and 3*s*. per 1 000 cubic feet as soon as the consumption would enable the Company to make the reduction out of the "excess of profits after paying their shareholders a dividend of 10 per cent." Needless to say, the Company never got below 4*s*. The Great Central Company also agreed to have inserted in the Act a clause giving free meters and service-pipes to consumers. They had power to pay deficiency in dividends of previous years that were below 10 per cent; and they were not compelled to form a reserve fund. The Act had a clause in it stating that the Company should not supply gas to any lamp or burner in any street, church, chapel, &c., in the east of London, except in the districts of the British Gaslight Company, the Ratcliffe Company, and the Commercial Gas Company, and then only on payment to such com-

panies of 40*s*. for every lamp or burner supplied. A similar penalty applied to certain parishes which were in the districts of the Gas Light and Coke Company and the City of London Company—penalties being recoverable.

The Directors adopted 9½ sperm candles as the standard of comparison for their gas, as recommended by Clegg; but the authorities fixed 12 wax candles in the Bill. Printed documents distributed said: "We will supply you with 9½ sperm candle gas as reported by Mr. Clegg, as a high average, at 4*s*. per 1,000 cubic feet, which, if you will take 300 millions per annum will yield a dividend of 10 per cent. If you take 450 millions, we will supply at 3*s*. 6*d*., and if 600 millions you shall have it at 3*s*.; for we are advised that quantity has an important influence over price."

It is worthy of note that under this Act of 1851 the supply of gas was voluntary on the part of the Company, though all legislation afterwards made it compulsory.

The Corporation of London has always taken a leading part in the gas affairs of the Metropolis, having expended over £29,000 in promoting Bills and Gas Legislation generally during the years 1860 to 1880, and in 1868 had a Bill in Parliament authorizing them to become the gas authority for the City of London, with works at North Woolwich.

The works of the "Great Central Gas Consumers' Company" were situated at Bow, and were opened in state by the Lord Mayor and Sheriffs of London, 1859, Croll being the constructional engineer and manager.

His Lordship addressed the assembled workmen in a speech on the origin, progress, present position, and future of the gas industry; this was followed by a dance, the festivities being kept up to a very late hour.

In his early life Croll was connected with the watch-making industry, afterwards becoming Master of the Worshipful Clockmakers' Company of the City of London. It was, perhaps, this early training in the highly technical work of watchmaking that caused him to turn his attention to the production of a dry meter for measuring gas. Croll, in conjunction with William Richards, C.E., invented the dry meter. The latter, describing the early experiments, said: "If a small balloon be attached to the Company's pipe and filled with gas, which is afterwards detached and pressed between two flat surfaces to expel the whole of its contents into any receptacle, it is certain that, if the capacity of the balloon be known, by this means gas could be measured with the same facility as liquids; for if it held exactly a cubic foot, each time on being filled that quantity of gas would be delivered by the Company, and on being emptied would be received by the consumer."

Clegg, in 'The Manufacture of Coal Gas, 1859,' writes, with a view to removing the objections to dry meters, previously introduced: "The 'Croll-Richards' meter secured, by a different application of the leather, that the gas should not be affected by the contraction or expansion of that material."

Mr. J. O. N. Rutter, of Brighton, in his work 'Advantages of Gas in Private Houses' (1854), remarks: "The Dry Meter has been in use about 23 years. During this period neither capital nor skill have been spared by its joint inventor and patentee, Mr. A. A. Croll, to make it what it has now become—an accurate measurer, not affected by sudden or extreme variations of temperature."

I gather that at one time there was some connexion between the firm of Glover & Co., meter makers, and Mr. Croll, for I have seen a dry meter bearing a plate with the following inscription: "Croll & Glover's Dry Meter, 1859."

Mr. Croll was also a Director of the Tottenham Gas Co., a successful Lessee of the Coventry Gas Co., Consulting Engineer to the Winchester Gas Co., and he also did yeoman service for the Jersey and Guernsey Gas Co. in its early days, and was Consulting Engineer and Agent in this country to the Shanghai Gas Co. up to 1870.

Thus the period of supply between the time of the passing of the Gas-Works Clauses Act of 1847, and the coming into force of the Metropolis Gas Act of

1860 was one of unrestricted competition. In 1848 the price of gas was 6*s.* per 1,000 cubic feet all over the Metropolis. The "cheap gas" agitation then spread to the south of the Thames; and Mr. John Thwaites, a draper in the Borough, who afterwards became Sir John Thwaites, the originator, and first Chairman of the Metropolitan Board of Works, was the prime mover. Sir George Livesey (then a lad, at the Old Kent Road works, under his father), speaking of these times, says: "1848 was my advent into the gas industry; and I remember quite well, as a youngster, attending a public meeting, and hearing Mr. John Thwaites speak. They demanded a reduction from 6*s.* to 4*s.* If the companies had been reasonable, and reduced it by 1*s.* to 5*s.*, I think it would have stopped the agitation; but the companies were obstinate, and persisted in the 6*s.* price."

and other companies had to do the same. On the passing of the 1860 Act, very few of the thirteen companies now in the Metropolis paid more than 6 per cent, which was looked upon as a good dividend.

In the City, previous to the advent of the Great Central Company, the districts of supply were partitioned out between the City of London Company and the Chartered Company, who alone supplied public and private lighting. The boundary of these two Companies was well defined, no attempt at infringement of it was made, and competition between them was unknown. Other companies were carefully prevented from laying down pipes. But though there was no competition, it was unrestricted outside, which enabled the authorities to submit these facts to the two Companies from time to time, and required what appeared

	City of London Company.	Chartered Company.		City of London Company.	Chartered Company.
	s. d.	s. d.		s. d.	s. d.
1823 .	15 0	15 0	1839 .	9 0	9 0
1824 .	15 0	15 0	1840 .	9 0	9 0
1825 .	15 0	15 0	1841 .	9 0	9 0
1826 .	15 0	15 0	1842 .	9 0	9 0
1827 .	15 0	15 0	1843 .	8 0	8 0
1828 .	13 6	13 6	1844 .	8s. and 7s.	8s. and 7s.
1829 .	13 6	13 6	1845 .	7 0	7 0
1830 .	13 6	13 6	1846 .	7 0	7 0
1831 .	12 6	12 6	1847 .	7s. and 6s.	7s. and 6s.
1832 .	12 6	12 6	1848 .	6 0	6 0
1833 .	10 0	11 3	1849 .	5s. and 4s.	5s. and 4s.
1834 .	10 0	10 0	1850 to 1860	4 0	4s. Competition by Great Central Consumers' Co.
1835 .	10 0	10 0			
1836 .	10s. and 9s.	10s. and 9s.			
1837 .	9 0	9 0			
1838 .	9 0	9 0			

Table of gas prices of "City of London" Company and the "Chartered" Company, from 1823 to 1860.

The result of the agitation was the immediate starting in South London of the Surrey Consumers' Company, also by Mr. Thwaites and Mr. Croll. This Company likewise started with the promise to supply at 4*s.* per 1,000 cubic feet. These two "Consumers' Companies," born of an agitation of aggrieved ratepayers and gas consumers, speedily brought down the price of London gas from 6*s.* to 4*s.* The South Metropolitan Company had been previously paying 6 per cent. They had to reduce this to 5 per cent;

to be a commensurate reduction in the price both in public and private lighting supply. The result was that, between 1823 and 1860, the price was reduced by the two Companies from 15*s.* to 4*s.*, as set out above.

In the year 1850 the contracts for lighting the public lamps having been advertised, the result was the letting to the new Company of the public lighting at a reduced rate. But the public had to submit to the inconvenience of having 1,650 holes opened in the paving. In 1852 tenders for lighting

were again received. The Chartered Company obtained the portion originally lighted by them, the Great Central Company retaining the remainder, and a further sum was thus saved. Owing to this reletting of a portion of the area to the Chartered Company, and the reconnexion of their supply-pipes and the disconnexion of the Consumers' Company's pipes, 1,093 holes were opened in the roads.

About this time William Perkin (afterwards Sir William Perkin) discovered the great Aniline Dye Process.

Competition Lessening.

The price of gas in the metropolis now stood at 4*s*., until the Companies were districted, which came about in this way: Mr. Thwaites, the originator of the Consumers' Gas Companies, was likewise the originator of the districting. The Surrey Consumers' Company, like the Great Central Consumers' Company, before they commenced had many promises from would-be consumers. But as soon as they were ready to start, the other companies reduced their price to 4*s*., and took off meter-rents. Then the customers who had promised to take their gas failed to keep their word. The Surrey Consumers' Company were in a great difficulty. Mr. Thwaites said, "I see competition is a failure." The Companies struggled on for a year or two, and then, in 1853, at Mr. Thwaites's suggestion, they agreed to divide South London between them. In 1854 the South London Companies having divided that portion of the Metropolis between them, went to Parliament for sanction for this districting; but, to use Sir George Livesey's words, "the feeling against this monopoly was so strong that Parliament refused its sanction," and so they went on under the agreement until 1860, when sanction was obtained.

In the year 1859, the Companies on the north side, profiting by the experiences of their *confrères* on the Surrey side, entered into an arrangement for terminating their competition, and divided the Northern Metropolis into districts, upon the principle of exclusive supply. The effect of this on the price of gas was that the very companies who had been formed from the consumers and ratepayers, and who had succeeded so well in their object, now that they felt the keenness of the competition they had brought about, immediately put up the price of gas from 4*s*. to 4*s*. 6*d*. per 1,000 cubic feet, at which figure it stood until 1860.

The raising of the price to 4*s*. 6*d*. caused an agitation to break out again. Complaints from local bodies and other consumers resulted in an inquiry being made as far as the Metropolis was concerned, which ended in the passing of the Metropolis Gas Act, 1860. The Bill was originally proposed by delegates from the gas consumers and authorities of the Metropolis, who, attended by a large array of counsel, parliamentary agents, and solicitors, were engaged before a Select Committee of the House of Commons for thirty days discussing its principles and details. It was introduced into Parliament quite early in 1860, and on April 2nd was referred to a Special Committee of the House of Commons.

Ultimately the Act passed in its present shape—the companies having obtained the withdrawal from it of those features which they considered prejudicial to their interests. Parliament, therefore, appears to have confirmed Mr. Robert Stevenson in the opinion that, by a well-regulated exclusive trade, gas consumers might be better and more cheaply supplied than by rival companies carrying on businesses with all the changes and losses which a state of rivalry produces.

In this Act a price was fixed of 4*s*. 6*d*. per 1,000 cubic feet for 12-candle gas; but the charge could be raised, on appeal to the Home Secretary, up to 5*s*. 6*d*. The districting was also legalised, so that competition was killed. The abolition of competition sanctioned by this Act, the fixing of the minimum price at 4*s*. 6*d*. for common gas of twelve sperm candles, and the increased consumption caused the companies to be very prosperous, excepting, perhaps, the Chartered Gas Company. The companies were paying full dividends (10 per cent); and the Act permitted them to pay back

dividends over a large number of non-prosperous years. This system encouraged the wasteful expenditure of capital. As new capital was allotted at par to the shareholders, it was only natural they should be clamorous for stock on such favourable terms and with such authorized dividends. Thus no inducement was offered to reduce the price of gas.

Among various petitions presented at this time to the local authorities against gas companies under the 1860 Act was one which stated that the Act gave the companies power to raise the price from 4*s.* 6*d.* to 5*s.* 6*d.* for common gas, and from 6*s.* to 7*s.* for cannel gas, and to change the gas at their own discretion.

Though much that has been written deals with the Metropolis, it must be borne in mind that London had been the fighting ground of the gas industry during the last fifty years. The industry was practically born in London; and the battles fought for and against the London Gas Companies, the agitations, competition, &c., coloured the legislation with respect to the industry as a whole. In 1861 the price of gas south of the Thames was 4*s.* 3*d.*, with a minimum charge (similar to the water companies) of 30*s.* per year, whether the gas was used or not.

It is interesting to note the names of the twenty-two companies in, and grouped around, London at this time: The Gaslight & Coke Co.; City of London Co.; Commercial Co.; Equitable Co.; Great Central Consumers' Co.; Independent Co.; London Co.; Phœnix Co.; Ratcliffe Co.; Surrey Consumers' Co.; South Metropolitan Co.; Western Gaslight Co.; Imperial Co.; Crystal Palace Co. (now the South Suburban Co.); Woolwich, Plumstead, and Charlton Consumers' Cos.; Woolwich Equitable Co.; Wandsworth and Putney Co.; Brentford Co.; Victoria Docks Co.; Eltham Co., Ltd.; West Ham Co.; and the Mitcham, Merton, and Tooting Co. The first thirteen only of the foregoing companies were entitled to be called "Metropolitan Gas Companies," with powers to "district."

In September, 1867, an interesting pamphlet was issued dealing with the labours in Parliament of the authorities during that Session in connexion with the Bills of the Imperial and the Chartered Gas Companies. The pamphlet was a reprint from the "*Journal*," and was published for distribution. It contained the speech of Mr. Deputy Bontems, the Chairman of the Special Gas Committee, who says: "Then look at the money spent in agitation! *The Journal of Gas Lighting* says that £100,000 have been lost in parliamentary expenses since the year 1857."

Revision of Prices.

With regard to the revision of prices, there were only three applications between 1868 and 1876—one in 1873, and two in 1874; and there is no doubt that they were brought about by the great coal famine in the early seventies. This famine, which began in 1872 and lasted till well into 1874, was at its worst in 1873, when prices had increased more than 100 per cent. It will be noticed that, by this Statute, the Revision Commissioners were directed to have regard to the question of management, and were only to allow such a price as would yield 10 per cent profit consistent with "due care and management."

In 1867 the consumption of gas in the Metropolitan area was increasing at an enormous rate. The quantity supplied to the large district served by the Imperial Co. doubled every ten years; and as the establishment charges were not increasing in the same ratio, the cost of supply per 1,000 cubic feet was naturally diminishing.

In the early part of 1868 there was issued an extremely interesting pamphlet entitled 'London Gas Companies and Gas Consumers: an Important and Exhaustive Article on this Great Public Question'; being reprints from *The Daily News* of that year. The title-page had on it the following: "Great misapprehension exists on the Gas Question; a portion of the Press—and notably *The Saturday Review*—having accused those who sought, and still continue to seek, for a reform in this gigantic monopoly, of a desire for confiscation. A Committee of the House of Commons, presided over by an

experienced and distinguished statesman, have investigated the matter, and have arrived at a conclusion still more unfavourable to the Gas Companies. This report has produced a renewed cry for confiscation, and an elaborate defence of the Companies by a Director of the Imperial Company—the largest, and, as last year's evidence showed, most unfair in its dealing with the consumers, of these great and uncontrolled monopolies. Four articles having lately appeared in *The Daily News,* written by an unknown hand, and these articles stating the position of matters with great accuracy and impartiality, permission was asked of the proprietors of that newspaper, and at once readily given, to reprint and circulate them. They charge to private consumers 4*s*., to the rich parish of Marylebone 2*s*. 11½*d*., and to the poor parish of Clerkenwell 3*s*. 7*d*., for the same quality and quantity of gas." One interesting point in the pamphlet is the cost of gas, at this time (1868), viz., it being certified by the engineers of five of the greatest London Companies to be 11¼*d*. at the works. One company, the West London Junction, who supplied all their gas to one consumer, had sold gas since 1859 at 2*s*. 10½*d*. per 1,000 cubic feet, and were prepared to sell any quantity at that price."

During 1868 a very strong pamphlet was issued by Mr. C. G. Cleminshaw, the engineer of the Manchester Gas Works, entitled the 'Gas Supply of the Metropolis: a Word to the Public, the Companies, and the Shareholders.' It was a scathing indictment of the thirteen gas companies of the Metropolis. In one place the author says that if the 1868 Session had been futile, the companies had been threatened with a Bill by which the consumer would have been supplied with 18-candle power gas at 3*s*. 6*d*. per 1,000 cubic feet.

There was also an article dealing with the question of the 10 per cent dividend of the gas companies, which contrasted the condition of things in London with those in Manchester (where the gasworks were in the hands of the Corporation), and concluded:—

"The language and attitude of the Companies are quite unreasonable; and they must be reminded that they exist for the consumers, not the consumer for them."

In 1868, in an article entitled 'The Gas we Burn,' in *The Leisure Hour,*[18] is the following quaint description of gas retorts:—

"Retorts are somewhat cylindrical in shape. We may add that shapes vary in different factories: some are strictly circular; a cross section of others would shew them in a greater or less degree oval; others, again, are waggon shaped, whilst many are known as 'kidney shaped.' The 'Waggon' or ⌓ shaped appear to be very generally used."

The article also states that "at the 'Equitable' (London) Gas Works, the processes of gas making are gone through, not merely without annoyance to the neighbourhood, but almost without any imperceptible odour in any part of the premises." Informing is the statement in the same paper that, in 1848, the amount of gas consumed in the Metropolis was 3,200 million cubic feet, sold for £700,000; whilst in 1868 it was at the rate of 12,000 millions, for which 1,200,000 tons of coal was carbonized; and the "consumption of gas doubles itself in the Metropolis every 10 years."

Compare this 3,200 million in 1848 with one Company alone in the Metropolis, which not long since had a record "day's output" of 30 million cubic feet.

Amalgamations.

In 1862 the Board of the Chartered Company were fortunate in securing the services of John Orwell Phillips as secretary, "under whose masterly sway" the policy of consolidation was carried out.

We now come to a rather important stage in gas lighting, so far as it concerns the Metropolis, when three of the companies, viz., the Chartered, the Central Consumers', and the City Company, were brought under the City of London Gas Act, 1868, in which the views of Lord (then Mr.) Cardwell's Committee were substantially incorporated.

18 *The Leisure Hour*, April 1, 1868, pp. 237-40.

Amalgamations were now the order of the day. In 1870 the Gaslight and Coke Co. purchased the Victoria Docks Gas Co. They also amalgamated with the City of London Co. in March, and the famous Great Central Consumers' Co. in July of that year, and in 1871 with the Equitable Gas Co.

It having been found in practice that the revisions of price by Commissioners were unsatisfactory, it was resolved to introduce Bills into Parliament for entering into competition with the existing gas companies by the erection of new works; for the acquisition, by purchase, of the property of those companies; and for the further regulation of the companies. Three separate Bills for carrying out these objects were introduced into Parliament, and were read a first time; but, owing to the Government not being prepared to support the second Bill, that and the first were withdrawn.

The remaining Bill, however, for the regulation of the companies, was proceeded with. Sir George Livesey attended, by order of the Speaker, at the instance of the Metropolitan Board of Works, and gave evidence as to the uselessness of existing regulations, and the necessity for a sliding-scale. His views greatly influenced the Committee, and he quoted from an address of his own the previous year to show that he had long been of the same opinion. Finally, on June 25th, after an immense amount of evidence had been taken, the preamble of the Bill was passed.

In 1870, owing to the sudden illness of Mr. Esson (the eminent gas engineer previously mentioned), who was at this time President-Elect of the British Association of Gas Managers, Mr. Magnus Ohren was unexpectedly called upon to fill the office of President of the Association. In his Inaugural Address he laid stress on the desirability and practicability of freedom from impurities, such as "visible sulphuretted hydrogen and ammonia."

This statement was followed by two papers on 'Purification,' one by Mr. Upward, of the Chartered Gas Company; and one by Mr. George Livesey, of the South Metropolitan Gas Company, on 'Scrubbers,' who explained an admirable arrangement by means of thin boards placed edgeways tier above tier, which he had used at his works, and which he said was very effective, never got out of order, and never needed changing. They stand at Old Kent Road to-day. Mr. John Ohren, of the Rio de Janeiro Gas Company, substituted plates of iron for trays of coke, with good effect.

It was at this time that the first mention of the "Iron Stoker" was made, in a paper by Mr. Somerville, of Dublin, who gave his additional experience of Best & Holden's "Iron Stokers." Mr. Magnus Ohren said he had seen the one at Dublin at work; and he also called attention to the "Iron Stoker" produced by Messrs. Dunbar & Nicholson for drawing and charging single retorts.

The address also dealt with the endeavours made to lighten Sunday labour, by Mr. Morton of the London Gas Co., Mr. G. Livesey, and old Peter Steele (who is still alive), who introduced the principle. It may be pointed out that a paper was read before the Association on 'Tar Pavements,' by Mr. T. H. Methven, of Bury St. Edmunds. But the most interesting item in the address was the allusion to the introduction of gas-cookers, Mr. Somerville, of Dublin, having first brought them into use at Maidstone.

Carburetted Water Gas.

Between 1873 and 1875 Prof. Thaddeus S. C. Lowe, a New Hampshire man, coming of a New England farming stock, invented and founded the carburetted water gas industry in the United States. Though it was used before his time, yet "it was the combination of process and parts designed by him that led to the introduction of the process on a commercial scale in this country. The combination of generator, carburettor, and superheater as a self-contained gasifying system was Lowe's design," which has proved so useful a "stand-by" gas plant in this country.

In 1876 the sliding-scale, the auction clauses, and a standard price were introduced into the Gaslight and Coke and South Metropolitan Companies'

Acts. A standard price was fixed, and also a standard dividend of 10 per cent, which could be raised 5*s.* per cent per annum for every 1*d.* taken off the price per 1,000 cubic feet. This 10 per cent dividend was to be reduced proportionately if the Companies increased the selling price above 3*s.* 9*d.* and 3*s.* 6*d.* respectively.

London cannot claim to be the originator of this system. It had already been put into the Sheffield Gas Co.'s Act in 1866, and in the West Ham Co.'s Act of 1869. But in 1874, at a meeting of the British Association of Gas Managers, Sir George Livesey dealt with the question. As far as London is concerned, Livesey may be termed the father of the gas companies' sliding-scale. Owing to the defective nature of the "one-way" sliding-scales of 1869 and 1874, however, they are no longer operative.

In January, 1865, the City of London considered the question of manufacturing its own gas.

In 1866 a Parliamentary Committee was appointed, under Sir John Trollope, to report on the 1860 Act, and the City of London Gas Bill, by which power was sought to establish a competing supply of gas.

dends when the price was below the maximum fixed. This might be termed a "one-way" sliding-scale.

Sir George Livesey, at a later date, says of this introduction of the sliding-scale: "Strange to say, all the Companies, mine included, refused the sliding-scale in 1875. Except the Commercial, the whole of the Companies were against me. Lord Grimthorpe, then Sir Edmund Beckett, who was Counsel for the Companies, in one of these (Parliamentary Committee) rooms, referred to me as 'this traitor; this Queen's Evidence.' Twelve months later, they came for the sliding-scale. My own Board were divided; three were in favour, two against, and so they went with the rest. Then those Companies I mentioned came to Parliament and applied for the sliding-scale."

There was still one Metropolitan Company without auction clauses in their Acts—the Commercial Company. These clauses were not inserted in this Company's Act of 1875. "Treated," says Mr. H. E. Jones, "with some favour by Mr. Forster's Committee in 1875, because they took the sliding-scale when the other Companies refused it that year, Mr. Forster in consideration did not impose the auction clauses

Companies' and Consumers' shares in the increased profits under the Siiding Scale of 1876, at per £100. (i.e. Amount required to reduce price by one penny.)	Companies.				Consumers.			
	1876.		1898.		1876.		1898.	
	Amount.	Proportion.	Amount.	Proportion.	Amount.	Proportion.	Amount.	Proportion.
	£	per cent	£	per cent	£	per cent	£	per cent
Gaslight & Coke Company	9,511	17·7	14,806	14·5	44,088	82·3	87,406	85·5
South Metropolitan Company	3,615	23·8	5,600	12·6	11,524	76·2	38,637	87·4
Commercial Company	1,529	24·9	1,877	16·1	4,623	75·1	9,756	83·9

After this came Mr. Cardwell's Committee, to consider the Bill brought in by the Board of Trade as an amendment to the Metropolis Gas Act (1860), in consequence of the report of Sir John Trollope's Committee of 1866. This Bill contemplated fixing a maximum price of 3*s.* 6*d.* for 14-candle gas, and limiting the dividend to 7 per cent where that price was charged, with a sliding-scale for increasing the divi-

upon them." The Commercial Co. did not have them introduced until twenty-seven years after, viz., 1902.

The object of the sliding-scale was to secure "due care and management" on the part of the companies, by giving them (as the letter of the Board of Trade to Mr. James Beal of the Metropolitan Municipal Association in 1874 stated) a strong interest to reduce their expenditure — the "strong interest"

being the power to divide more than 10 per cent. The foregoing table (compiled by Mr. Haward) shows the companies' and the consumers' shares in the increased profits under the sliding-scale at per £100 in 1876 and 1898. (For table see previous page.)

In 1883 the last of the amalgamations of the old Metropolitan Gas Companies took place (viz., the London Gas Co., whose area was partly on the north and partly on the south of the river, in the Strand and Lambeth respectively, with works at Nine Elms), after long negotiations, the date of the Order in Council being May 22nd, 1883. At last the Chartered Co. got astride the river.

Somnolence and Inertia.

An end was now brought to a long period of agitation, conflict, and trouble, extending over twenty-eight years (from 1848 to 1876), during which period "arranged areas," "fierce competition," "authorized districting," "amalgamations," and "statutory monopoly" had all had their part; and now, just when the gas companies were working in harmony, and competition and agitation had ceased, a fresh form of competition sprang up in a new illuminant — electricity — which caused almost as much wonder as gas lighting in its early days.

Following this date and the early eighties a somnolent and reposeful period set in, and the industry was in danger of suffering from a very bad form of inertia, caused chiefly, one may suppose, by the absence of competition and the payments of high dividends by many companies, for in London the Gaslight & Coke Co. and the Commercial Co. were paying as high as 13¾ per cent in 1889, and the South Metropolitan Co. were dividing 13⅛ per cent the year previous. *No one complained!* but the incentive to energy and invention seemed to have become stagnant. There were, however, a few who kept the torch burning brightly—*e.g.*, the veteran Thomas Newbigging, of Manchester, in the North; Mr. Charles Hunt, of Birmingham, in the Midlands; and Mr. George Livesey, of London (as he then was), in the South, seconded by the able engineer of the Phœnix Co., Mr. Corbet Woodall (now Sir Corbet), and Mr. H. E. Jones, of the Commercial Co., the first three of whom received the Institution (Birmingham) Gold Medal in the years 1890, 1886, and 1882 respectively, whilst the fourth-named gentleman is recommended for the same this year.

Electric Competition.

Electric lighting experiments went on in various parts of the Metropolis, and direful pictures of the downfall of the gas industry were drawn. In 1884 Sir W. H. Preece, the engineer to the General Post Office, reported on experiments made with Edison and Brush lamps in London; and in 1885 Col. Haywood (the City Engineer) made an interesting report as to the municipality supplying electricity itself, in which he mentioned the complete stagnation in electrical enterprise in England, attributable to the operation of the Electric Lighting Act, which "fettered the industry in a variety of ways." In the end he was entirely against the municipality supplying electricity itself, but advised that it should encourage commercial enterprise. In 1883 Sir W. H. Preece, reporting on the electric light experiments, stated that, though the streets of London were fairly lighted by gas, it had been proved, both by gas and electrical interests, that the illumination could be very materially improved; and his opinion was that, for street illumination, all the conditions could be obtained as well by gas as by electricity.

In 1890 there were 160 applications for Electric Lighting Orders in the United Kingdom, twenty-three of which were for London.

In spite of adverse criticism, experiments proceeded with this new form of lighting; and the Thames Embankment was lighted by Jablochkoff lamps. Later on, companies sprang up all over the country, and municipalities applied for Electric Lighting Orders, and commenced to light the streets with arc lamps at great cost.

FIG. 4.—Mr. Thomas Newbigging, C.E.

FIG. 6.—Sir George Livesey, C.E.

FIG. 5.—Mr. Charles Hunt, C.E.

FIG. 7.—Sir Corbet Woodall, D.Sc.

The Industry Awakens.

A nervous tremor was now passing through the ranks of those engaged, or interested in, the manufacture or sale of coal gas. Like a great giant awakening out of sleep, the industry aroused itself from its state of lethargy and threw off its indolence; but the prophets who foretold the doom of gas lighting were many. The manner in which these dire predictions were not fulfilled is now a matter of history. *Invention*, which, happily, is not the monopoly of any particular industry, saved the situation. It was busy, no doubt, among the pioneers of the new rival, but it was none the less active amongst those who held in trust an industry grown vast in spite of all the vicissitudes of three-quarters of a century.

The Incandescent Mantle.

It was at this time, when gas companies throughout the Kingdom were being "hard hit," that the wonderful invention of Dr. Auer von Welsbach (who received the Institution gold medal), the incandescent gas mantle, was brought to the notice of the world; and, although its price in this country (1*s*. 3*d*. each), and fragility, coupled with prejudice, and a certain amount of hesitation on the part of the gas companies, retarded its adoption for some time, it was found, on account of its cheapness, by reducing the consumption of gas, and giving three to four times the illuminating value, to be a very serious rival of the incandescent electric lamp for indoor purposes.

The romantic story of Dr. Auer von Welsbach's discovery in the early eighties has been materialized before our eyes, taking us back to that world-renowned and most celebrated laboratory at Heidelberg, where Henry Roscoe, then an assistant to Bunsen (but later known as Sir Henry Roscoe, one of the leading expert chemists in this country), pointed out to his chief that a non-luminous flame could be obtained by passing coal gas a short distance through air, and then taking it through a piece of wire gauze, known afterwards to the world as the Bunsen flame. To-day they see the marvellous value of this simple discovery at the Heidelberg University—the birthplace of both the Bunsen flame and the incandescent mantle. Dr. von Welsbach could have had no conception when he discovered the light-giving properties of the salts of the rare earths to what dimensions and changes it would lead, and its great effect upon the gas industry.

How simple was the discovery! He was boiling a solution containing salts of the rare metals, when the liquid boiled over and evaporated on the fibres at the ragged end of an asbestos card, which was used to support the

Fig. 8.—Mr. H. E. Jones, C.E.

beaker; the flame was playing round the card, and Dr. Welsbach noticed that the salts became luminous. He devised a mantle to fit over the Bunsen burner, and after hard work his researches were crowned with success.

Each time I have been in that old city watching the crowds of students thronging its long and narrow High Street, my thoughts have always reverted to those three great men—Bunsen, Welsbach, and Roscoe.

It is now nearly thirty years since Welsbach first applied the Bunsen

flame to make heat supply light; and soon afterwards a gentleman, hot from the works of Welsbach himself, came to the City of London, and called at the Guildhall with a request to be allowed to put up what he called a "stocking," to show what he could do at 1*s.* 3*d.* each. The "stocking" was a very fragile affair; and on the day after it was fixed the author found a little heap of dust on his blotting-pad. That was the end of the first Welsbach mantle he knew in the City. How things had altered since that time we are all aware.

During the last quarter of a century the system has spread so rapidly that flat-flame burners are getting quite uncommon, and we are now, after fifty years, able to see what the industry owes to this simple discovery—the non-luminous flame: cookers, gas fires, gas boilers, gas irons, industrial appliances, but by no means the least, incandescent lighting.

Popularization of Gas Lighting.

Still, in the eighties, gas was being gradually displaced in the large buildings of the chief cities and towns, when an additional aid came to its rescue in the shape of a meter specially designed to fulfil the requirements of the working classes, and known as the automatic or penny-in-the-slot meter. This, together with the incandescent mantle and the increased popularity of the gas-cooker, saved the situation for the gas industry. Now was coming to pass the wish expressed, nearly a century ago, by Mr. Accum, that the dwellings of the working classes might be lighted by the "new illuminant," for, strange as it may seem, the gas industry at this time had not succeeded in enlisting among its customers, to any large extent, the small householder, the tenant of two or three rooms, and the large number of inhabitants of blocks and artizans' dwellings.

The workman preferred to burn oil and to cook by coal, to having to pay a quarterly gas bill, in addition to paying a deposit and signing an agreement at the offices of the company, which in his case meant very often a long journey and loss of time and wages, in addition to his having to undergo the humiliating process of practically standing on the mat, with his hat in his hand, outside the inspector's room, for an indefinite period, and then being treated with scant courtesy when once admitted. Thus, with the electric light taking the richer customers, and the cheap oil holding the smaller ones, in 1892 the South Metropolitan Gas Co. began to turn their attention to new ground. Very few weekly tenants used gas; so that it could be taken as fairly correct to say that gas was practically unknown in the dwellings of the working classes. They would never, in addition to the reasons already given, incur the cost of putting in gas-fittings and pipes. Sir George Livesey, in his statement on slot-meters handed in to the House of Commons' Committee in 1899, said: "This difficulty might have been overcome by monthly collections, if the demand had arisen, and the question of fittings could have been dealt with."

Penny-in-the-Slot Meters.

It is well to remember that slot-meters were first introduced into the Metropolis in 1888 by the South Metropolitan Co. in a small way. There seemed but little chance of their coming into general use, so that they were dropped. Later on, in 1892, it became known that the Liverpool Gas Co. had taken them up, and made them "go." The meter was introduced to the manager of the Liverpool Co., and he said, "I will try it." He ordered 500; and the thing "went like wildfire," and in a few months they had orders for 8,000. "This fact," to use the words of the Chairman, "induced the South Metropolitan Co. to go into the matter in earnest"; and, before the end of the year, they had 439 fixed. By the end of 1893 the number was 6,166, and during the next year the total reached the respectable number of 25,516; and in 1898, 80,115. It was seen that these meters had "come to stay"; "it was sufficient," said Sir George Livesey, "to turn the scale in the annual output, and prevent any decrease." "We adopted the system of

canvassing," said the South Metropolitan Chairman, "giving all our employees the option of doing this; and a certain bonus was given for each consumer they brought to the Company; we made no distinction—some were lamplighters, some index-takers, some gasfitters, and some labourers." A keen spirit of rivalry was set up among the workmen to go out and fetch would-be consumers in. To give an idea of the growth of this business, Bristol might be cited as having, in 1902, twenty "coin-freed" meters; while the number they had out in 1906 was 16,157. The large cookers for ordinary consumers were also becoming much sought after; and builders, in erecting new houses, made provision for fixing them. In 1906, to mention only two instances, the South Metropolitan Co. had no less than 267,000 gas cookers and fires of all kinds in use; while the Gaslight & Coke Co. issued during the same period 110,000 additional cookers, giving them a net increase for that year of 57,000 on this class of goods. To regulate the price of gas to consumers using prepayment meters, Parliament, in 1900, fixed it at 10*d.* per 1,000 cubic feet above the ordinary price, to cover cost of fitting and hire.

Smoke Abatement.

Thus, with the "Gas Cooker," the "Gas Fire," the "Penny-in-the-Slot Stove and Ring," and cheap coke for domestic fuel, the fog problem seemed to be in a fair way to be settled in large cities and areas of dense population, for the workman now cooked his breakfast on the gas ring, and hundreds of thousands of domestic chimneys, the greatest of all offenders in polluting the atmosphere, were now smokeless in the early morning.

But another factor in allaying this nuisance, and at the same time providing a cheap fuel in small quantities for the poor people, came into operation, viz., "Paper Bag Coke." Dr. Carpenter informs me that it "originated about the same time in Germany and America, and was first sold in this country in very small quantities to the poor in 1908 by the Tottenham & Edmonton Gas Co." Mr. A. E. Broadberry, the engineer and manager of that Company, has kindly given me the following information: "The first I knew of it was that Sir Corbet Woodall started it at the Gaslight & Coke Co., under the impression that it would be just the thing required for occupiers of flats. The 28 lb. bag of coke was the right size for the little goods' lifts installed in most of these buildings, and being a much cleaner fuel than coal, he anticipated that there would be a good demand. We have practically no flats in our district, but it seemed to me that a good trade might be done in coke packed in this way by means of greengrocers, oilshops, &c., and I therefore arranged to sell to shopkeepers in quantities of not less than 12 bags at wholesale prices, giving them a penny per bag profit."

It would be incorrect not to mention the great gas inquiry held in 1899 by Parliament, in answer to the agitations all over the Northern Metropolis in favour of cheaper gas. The inquiry continued during the whole length of the session; and the findings of the Committee foreshadowed a reduction in the standard price, a lowering of the candle-power, and a restriction of future capital powers when any of the companies came to Parliament. These effects were made operative upon the South Metropolitan Co. in 1900, the Commercial Co. in 1902, and the Gaslight & Coke Co. in 1903. The illuminating power of the first two companies was reduced from 16 to 14 candles; and the standard price and the statutory dividend of all the companies were lowered.

Passing to another subject of great importance that took place about this time, viz., the legislation with regard to sulphur compounds, which freed the gas industry from harsh restrictions that barred its advancement, it is of interest to note the effect of such freedom upon the Gaslight & Coke Co., whose "works' cost" for 1906 had been reduced by some £14,000 in purification. This service, rendered to the gas industry by Sir George Livesey, caused Mr. Charles Hunt to speak of the author of this legislative enactment in the following words: "The indomit-

able pluck, perseverance, and tactical skill with which he fought the fight to a finish. . . . But for him, it is impossible to say how much longer the industry would have had to labour under the double disadvantage of compulsory lime purification and high illuminating power. But for him, our progress must have been halting and unsatisfactory. It matters not that the battle fought was that of the London Gas Companies, the victory remains with the gas industry as a whole. A momentous step forward has been accomplished; and the gas manager may henceforth devote his time and energies to more profitable use than watching for fluctuations of a few grains of sulphur compounds, or for rushlight changes of candle power." A worthy tribute to one who, from the year 1848, had devoted himself to the benefit and advancement of the gas industry of the United Kingdom.

This history of gas lighting would be incomplete were reference not made to the great strike at the South Metropolitan Gas Works in 1888, the threat of the gas stokers at this period to plunge London in darkness, and the introduction of the co-partnership scheme. The story of that great struggle is fresh in the memory of most men—how the brothers George and Frank Livesey withstood the demands of the strikers, and carried on the business.

As to Sir George's great work for the gas industry, it was my privilege recently to refer to this in the course of a short *résumé* of the chief events in the hundred years of gas lighting. Let me repeat a few remarks made on that occasion :—

"In compiling this history, I have in no wise gone out of my way to introduce the name of Sir George Livesey; but in my research the name so continually cropped up during the last forty or fifty years of the gas industry, that I was compelled to insert it as frequently as I did. The only compunction I have is in having done so little justice to one who, by his intelligence, foresight, tact, and determination, has done so much to raise the industry to its present proud position, and whose name will rank with that of Clegg, the great gas engineer of the first forty or fifty years, who, by his inventive faculty and indomitable courage, lifted the industry from the rut in which it had found itself in those early days." I desire also to put on record the encouragement I received from him, when, in 1903, with a few others, I was endeavouring to form the Southern Junior District Association.

I well remember the dark eighties, when Sir George called upon his fellows to follow him into new paths; and if asked whether he was successful in the great task to which he then put his hand, would point to the hundreds of representative men who attended, uninvited, his funeral at Nunhead, but more especially to the great and solemn procession of 7,000 of his workmen, who silently followed to his last resting-place the one who had enriched them in a far higher than financial sense—namely, by his personal contact with them.

Statistics of Progress.

The literature pertaining to the industry has been both prolific and exhaustive; there is no need for me to mention them, as they have been set out by Mr. F. Southwell Cripps, C.E., in his 'Earliest Works on Gas Lighting, 1907,' in the 'Hundred Years of Gas Enterprise' (by Mr. T. Newbigging, C.E., 1901), and by Mr. Charles Hunt, C.E., in his 'History of the Introduction of Gas Lighting,' 1907.

In 1881, Robert Louis Stevenson, writing from Davos Platz, included "A Plea for Gas Lamps," in which he makes the children say, "God bless the Lamplighter." [19]

It would not be right to pass over in silence the work of the technical press:—the *Journal of Gas Lighting*, the *Gas World*, the *Gas Engineers' Magazine*, and others, that, by their exhaustive contributions have added so much to Gas Works Technology.

Earlier in this lecture we dealt somewhat fully with the causes leading to a diminution in the price of gas.

19 "Virginibus Puerisque," 1907, p. 187 (Chatto & Windus, London).

A word might be said here as to the new development on the administrative side of the undertaking that is now going on, both inside and outside the Board Room, with the result that old prejudices against the industry are dying. The old titles "Gas Man," "The Man with the Shovel," no longer hold. The gas representative is no longer "the man with the shovel," nor does the old "rule of thumb" practice prevail; there is no longer any "muddling through."

For gas engineers and leaders in the industry the best men only are required. A University education in scientific research is not unbefitting. as shown by the Scientific University of Leeds lately conferring its degree of D.Sc. on Sir Corbet Woodall and Mr. Charles Carpenter. In fact, the industry claims the best; whilst with regard to the rank and file, "Fittings Departments," "Sales Departments," "Publicity Departments," "Special Experts and Advisors," "Lady Demonstrators," "A New Order of Inspectors," "Revival of the Apprenticeship System for Lads," "Practical Training Classes for Mechanics," and better education for workmen generally inside the works, are all steps in the right direction.

The Institution also stands on a higher plane than ever. Commercial sections are springing up, the Association of British Gas Industries has been formed, whilst the work of the district associations and the junior societies tends to the enlightenment and advancement of its members. Before leaving this subject I would like, if not presuming, to say there is every incentive for the leaders of the gas industry, whether of municipally controlled or privately owned concerns, to cheapen the price and remove any restrictions as to supply; and all—copartners, shareholders, and directors, from the man on the district to the chairman at the board—are, I believe, working together to-day in the interest of the consumer, to afford him a cheap and unrestricted supply of light, heat, and power to enable him to carry on his industrial pursuits, heat his dwelling and public buildings, cook his meals, and light his home and his streets.

The following table gives the price of gas in London from 1823 to July 1, 1913. Previous to 1823, a considerable portion was sold by "rental."

TABLE OF PRICES CHARGED FOR LONDON GAS FROM 1823 TO JULY 1, 1913.

Date	Price per 1000 Cub. ft.	Date	Price per 1000 Cub. ft.	Date.	Price per 1000 Cub. ft.
A					
1823	15 0	1856	4 0	1889	2 3
1824	15 0	1857	4 0	1890	2 3
1825	15 0	1858	4 0	1891	2 3¾
1826	15 0	1859	4 0	1892	2 6
1827	15 0	1860	4 6	1893	2 5¼ aver.
1828	13 6	1861	4 6	1894	2 4¼ ,,
1829	13 6	1862	4 6	1895	2 3½
1830	13 6	1863	4 6	1896	2 3
1831	12 6	1864	4 6	1897	2 3
1832	12 6	1865	4 6	1898	2 3
1833	11 3	1866	4 6	1899	2 2
1834	10 0	1867	4 6		2 1
1835	10 0	1868*	3 3	1900	2 1
1836	9 6	1869	3 3		2 4
1837	9 0	1870	3 2		2 8
1838	9 0	1871	3 1	1901	2 8
1839	9 0	1872	3 0		2 3
1840	9 0	1873	3 0	1902	2 3
1841	9 0	1874	3 0	1903	2 3
1842	9 0	1875	3 0	1904	2 1
1843	8 0	1876	3 6†		2 0
1844	7 6	1877	3 2	1905	2 0
1845	7 0	1878	3 0	1906	2 0
1846	7 0	1879	3 0	Jan. 1 1907	2 0
1847	6 6	1880	3 0		
1848	6 0	1881	2 10	July 1 1907	2 3
1849	5 6	1882	2 10		
1850	4 0	1883	2 10	1908	2 5
1851	4 0	1884	2 8	1909	2 4
1852	4 0	1885	2 8	1910	2 2
1853	4 0	1886	2 6	1911	2 2
1854	4 0	1887	2 5¼ aver.	1912	2 2
1855	4 0	1888	2 5	1913	2 2

Whilst the Wandsworth and Putney Co. are charging 1*s.* 9*d.* per 1,000 ft.

* From 1868 the South Metropolitan Company's prices are quoted, theirs being the lowest.

† Average for the year, 3*s.* 0½.

A. Previous to 1840 a "rental" charge per burner was made.

THE FUTURE.

There have not been wanting critics—honest doubtless—who have been ready any time during the last thirty years to predict the decay of the gas industry. Needless to say, the critics have had some reason for their views, but the assertion that gas has become a necessity of life is now admitted. The residual products have become indispensable to the carrying on of many other important industries. Nothing is more remarkable than the rise of the vast industries, employing a multitude of workers, called into existence during the last half century in the production of apparatus for the manufacture, distribution, and utilization of gas for

lighting, heating, cooking &c., glassware, iron and brass ware, and other trades, all benefiting.

So great are the ramifications of the industry, so deep down have its roots gone into the community, that what with the allied trades and the great chemical industry, the result of depleting the industry would mean the ruin of many trades in the country and a general disturbance of its economic conditions. There is room for electricity and gas: both are here, and to stay.

In spite of the growth of electricity, more gas is used to-day than at any time in the history of the industry, and in the table below I have summarized from the *Gas World* Year Book for 1913 some statistics that give some idea of the dimensions to which it has grown.

Gas Companies in the United Kingdom and Ireland, 1913	No. of Gas Undertakings.	Annual Make.	No. of Consumers.	No. of Slot Meters.	No. of Cookers	Public Lamps.		Daily Capacity of Water Gas Plant.
						Total.	Fitted with Incandescent Burners.	
*Total	1,620	210,499,343 000	7,143,718	3,541,925	3,228,642	769,240	678,320	243,865,000

* 'Gas World Year Book, 1913.'

One remarkable evidence of the continued growth of the industry in the United Kingdom is given by Mr. T. Newbigging in his work, *i.e.*, "Notwithstanding competition by other illuminants, the consumption of gas throughout the country has doubled in the last 17 years (1901). This is at the compound rate of $4\frac{1}{4}$ per cent per annum."

Whilst turning to the Metropolis, I find, on looking up for "record day outputs," that the Gas Light and Coke Co., on Dec. 22nd, 1890 (when everybody was using gas and it was the illuminant for the public lighting), sent out 125,721,000 cubic ft. On Dec. 22nd, 1891, the figure was 128,207,000, whilst on Dec. 15th, 1899, the amount sent out was 130,829,000. At this time electricity was in fairly good swing. This was before the Company amalgamated with the West Ham, Barking, and Chigwell companies; to-day the figures are, of course, enormously greater.

This history throughout has been but a chronicle of facts, and in no way reflects the opinions of the writer, who, however, takes this opportunity of stating his belief that—given cheap gas supplied at a higher pressure than formerly, of a low illuminating power, and of high calorific value to meet the altered circumstances—there is no finality for the purposes and uses for which gas can be employed during the coming century.

What the future holds in its hands for the gas industry is beyond human ken, especially in view of the many scientific achievements of the last two decades. It is hard to say which is the more interesting at the present moment—to look back on the developments of past years or to speculate on the possibilities of years to come.

Truly the difference between age and youth is that the former is prone to grow reminiscent and point to the years gone by, whilst youth, ever looking towards the dawn, sees the advancing years full with possibilities; and as there are so many members of the junior associations here present to-night, I would, in closing this portion of my discourse, use the stirring words of that great veteran, Mr. Thomas Newbigging:—

"A new century has dawned upon us. What gifts has the twentieth century in store for the gas profession? Only such gifts as the members of the profession *will* for themselves and their art. No more; no less!.....There are rich crops awaiting the cunning hand of the husbandman, and they will spring to life at the touch of the coming genius."

PART II.

Use of Gas as an Illuminant.

Mankind has always divided the day as between light and darkness. Before artificial light was in general use the public streets were emptied and, as nightfall approached, men betook themselves to their houses for rest, safety, and sleep. Beckmann, in his work on 'Inventions,'[1] says: "The lighting of streets, whilst it greatly contributes to ornament our principal cities, adds considerably also to the convenience and security of its inhabitants. But of whatever benefit it may be, it is generally considered as a modern invention."

M. St. Evremond says: "The lighting of the streets of Paris during the night by a multitude of lamps deserve that the most distant Nations should go and see what the Romans and Greeks never thought of." "This opinion," says Beckmann, "appears to be well founded, for I have never yet met with any information which proves that the streets of Rome were lighted." This would account, no doubt, for the large use of flambeaux and lanterns necessary for the use of the Romans on their return from their nocturnal visits. Whoever walked the streets of Rome at night without a lantern was in great danger[2] like Alexis in Athenæus.

Meursius endeavoured to make it appear that the streets of Rome were lighted, and in support of this view quoted Ammianus Marcellinus, and the Life of Julius Cæsar in Suetonius.[3] That Naples was not lighted appears from a return in the night-time, mentioned by Petronius.[4] Circumstances related by ancient authors make it probable that Antioch, Rome, and a few other cities had lanterns in those streets most frequented, for does not Libanius in the fourth century, when singing the praises of his native city, Antioch[5] mention that the ropes from which the "centrally hung lamps" were suspended were cut by some riotous soldiers not far from a bath—"to a bath not far off they cut with their swords the ropes from which were suspended the lamps that offered light in the night time"—indicating that lamps were suspended near baths and places of general resort. The following passage from Jerome seems to make it certain that, at Antioch, the streets were lighted. For in the altercation between a *Luciferan* and an Orthodox, he relates that an adherent of the schismatic Lucifer disputed in the streets with a true believer until the streets were lighted.

In Dominicus Vallarsius we have a short dissertation on the time when this unmannerly dispute took place; the author gives it as taking place at Antioch in the year 378.[6]

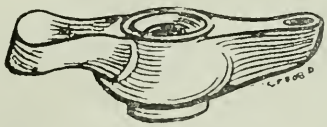


Fig. 9.—Roman oil lamp (domestic).

Basilius the Great in a letter to Martinianus speaks of the miserable state of his native city, Cæsarea in Cappodocia, and says: "They had nights without lights (*Noctes non illustrata*)"; in the year 371.

Of modern cities, "Paris, as far as I have been able to learn," says Beckmann, "was the first that followed the Ancients by lighting its streets." But, then, this city, at the beginning of the sixteenth century, was so infested with robbers and incendaries that the inhabitants were ordered to keep lights burning before the windows of all the houses which fronted the street. The order was issued in 1524, and renewed in 1526 and 1553;[6a] but in October, 1558 *falots* were erected at the corners of the streets, or if the street was long, then also in the centre of them. A *falot* was a large vase filled with pitch, rosin, or other combustibles, employed in the King's Palace and houses of princes

1 'History of Inventions,' Beckmann, vol. ii. Translated by Wm Johnston (1846), p. 172.
2 Athen. Deipn. vi., 8, p. 236.
3 Joh. Meursii Opera, Florent, 1745, f. v., p. 635.
4 Pet. Cap. lxxxix.
5 Libanii Opera Lutet 1627, f. ii., p. 387.
6 Beckmann, vol. ii. p. 173.
6a Historie de la ville de Paris, Felibien Paris 1725, 5 vols. folio. See vol. ii., pp. 951-77.

to light their courts.[7] At that period there were in Paris 912 streets, and it is computed that the number of lights used was about 2,736. In November this year the *falots* were changed for lanterns. In March, 1662, the Abbé Laudati, an Italian of the Caraffa family, conceived the idea of letting out torches and lanterns for hire, and obtained the exclusive privilege for twenty years, and undertook to erect at certain places in addition to Paris, booths or posts where persons might hire a lantern or link, or for a certain sum be attended through the streets by a man bearing a light, at so much per hour by a time-rate, and, to prevent disputes, an hour-glass was carried with each lantern. (An early record of a cautious lighting contractor.)

"Watchman—what of the night?"
FIG. 9a.—One of the old time watchmen.
(From "Sermons in Candles.")

In 1667 the lighting of Paris was put on a proper footing, and served as a pattern to most of the other cities of Europe. In 1766 a journeyman glazier, named Goujon, received a premium of 200 livres, and Messrs. Bailly, Le Roy, and Bourgeois de Chateaublanc 2,000 livres, for discovering the most advantageous means of improving the lighting of the streets.

7 Grand vocabularie de Francois.

"In a small work entitled an 'Essay on Lanterns,'[8] written by a Society of Literary men, there is some useful information respecting the lighting of streets, and we are told the reverberating lamps (in Paris) were invented by an Abbé P., who therefore [says the author humorously] is the Second Abbé who can boast of having enlightened the first City in the world."[9] "The superiority of these lamps cannot be denied [says the author]; but, beside the expense they are attended with this disadvantage when they hang over the middle of the street, that they throw a shadow over it, so that one cannot be known to those that pass. In Cities also, where people walk principally in the middle of the street, or where the streets are broad, they are not very convenient, and they occasion a stoppage when it is necessary to clean them."

This is another early reference to "centrally hung lamps," but it is evident they had not clear globes at the bottom, and certainly they had no "lowering gear."

In 1771 the number of street lamps was said to be 6,232.

In 1777 the road between Paris and Versailles, which is about 9 miles in length, was lighted. The city of Nantes was lighted the same year, and in 1780 had 500 lamps. Strasburg began to be lighted in 1779; Birmingham in 1733, with 700 lamps. I do not know of any records proving that the Romans, during their occupation, ever lighted the streets of London. The finds of Roman and Roman-British remains during modern excavations have been very numerous and very rich, especially in lamps, as evinced by the very beautiful collection in the Guildhall Museum, but they are all of the domestic type of earthenware. If what Maitland[10] says is true, that in the year 1414 an order was issued for hanging out lamps, and if that regulation was continued, then must it be allowed that London preceded Paris in this matter. Maitland

8 'Essai sur les Lanternes,' A. Dole, 1775.
9 Street Lighting, Beckmann's 'History of Inventions,' 1846, vol. ii., p. 177.
10 'History of London' (London), 1756, 2 vols., folio i. p. 186.

refers for his authority to Stow's 'Survey of London,' but in the 1633 edition is found only the following information: "1417. Mayor—Sir Henry Barton, Skinner. This Henry Barton ordained Lanthorns with lights to bee hanged out on the winter evenings, betwixt Hallontide[11] and Candlemasse." Nothing more occurs in the edition by Strype in 1720.

In 1668, following the Great Fire, several regulations were made by the City for improving the streets, under the direction of Sir Christopher Wren; and Londoners were reminded that they should "hang out their lamps duly at the accustomed time."[12]

In 1690 this order was renewed, and every housekeeper was required to hang out a lamp *every* night, as soon as it was dark, between Michaelmas and Lady Day, and keep it burning until 12 o'clock at night. In 1716 the Court of Common Council ordained that all housekeepers whose houses fronted any street, lane, or public passage should on every night, according to the moon, hang out one or more lights from 6 to 10 P.M., under penalty of one shilling. "All these regulations, however, seemed to have been ineffectual, owing to bad management. The City was lighted by contract, the contractors paying annually to the Corporation the sum of £600."[12a] The contractors only received 6*s*. from each housekeeper whose rent exceeded £10, and any person who hung out his own lamp was exempt from paying towards the public lamps. As the streets were only lighted 117 nights a year great opportunity was given to thieves to commit depredations; therefore the Lord Mayor and Commonalty judged it proper to apply to Parliament in 1736 for power to enable them to better light the streets of the City. The Act gave the Corporation power to erect such glass lamps as they thought proper, and to keep them alight from sunset to sunrise through the year; the number of lamps was increased to 4,679, but as they were not sufficient, several of the wards made a considerable augmentation, bringing up the number to 5,000 in the City and its liberties. Maitland, the historian, reckoned that this was only a fifth of the area of the Metropolis; that there were at least 15,000 lamps in use in the capital.

In 1774, owing to the great number of robberies, it was found necessary to apply for another Act of Parliament to regulate and still further light the City. The lamps of London, in 1786, were all of crystal glass, each furnished with three wicks fixed to posts, and systematically spaced. At this period Oxford Street was said to have more lamps than all Paris, and, seen from the high ground of the county of Surrey, they were said to "have a very beautiful and noble effect."

The difficulty of getting the citizens of London to light their portions of the streets properly and the trouble they caused the Corporation is quaintly set out by the Rev. C. H. Spurgeon in a set of lectures to his students[13]:—

"Old records inform us that the Commonalty, as expressed by the elected representatives, and those who elected them, were continually at variance as to the effectual lighting of the public streets. One edict was to the effect that every citizen should exhibit a candle over his door. The law was obeyed, but the candle was not lighted. A further regulation, it is said, was made that everybody should light the candle by law 'exhibited.' He did so; but after it had been lighted, the wind would blow it out, and the citizen saved his tallow. The regulation was then amended, and it was decreed that all should hang lanterns over their doors. This was quickly done; but as nothing was said about candles, they were left out. The authorities went over the ground again, and decided that the lanterns should have candles therein. Once more the law was obeyed; but the candles were not lighted. It was next decreed that the lanterns should be lighted; and careful citizens only put in very small pieces of candle which soon burnt out. The length of the candle to be lighted

11 Halloween.

12 Noorthouck's 'History of London' (London), 1773, 4to, p. 223.

12a Beckmann, vol. ii., p. 178.

13 'Sermons in Candles,' by C. H. Spurgeon, London, 1891.

was then specified; but the controversy has never ceased." Instead of being fought around "candles," it has

FIG. 10.—Old rushlight holder.

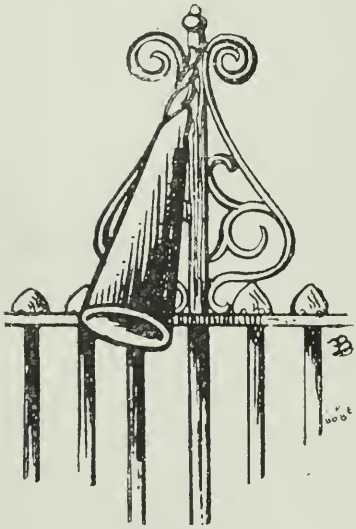


FIG. 12a.—Sketch of torch extinguisher.

waged around "candle power," with an intensity that makes the battles of those crucial days appear quite small things. So badly were the public streets lighted in the days of "Bluff King Hal" that highway robbery was committed with impunity. "Hang up the thieves, and let honest men stay indoors," was the King's advice; and

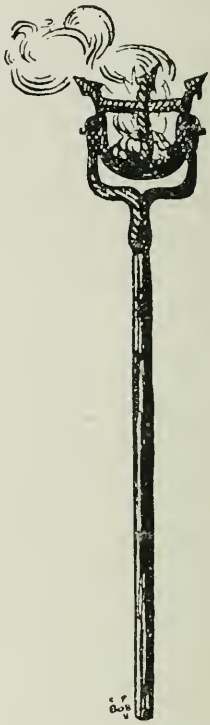


FIG. 11.—The burning cresset carried by troops or watchmen.

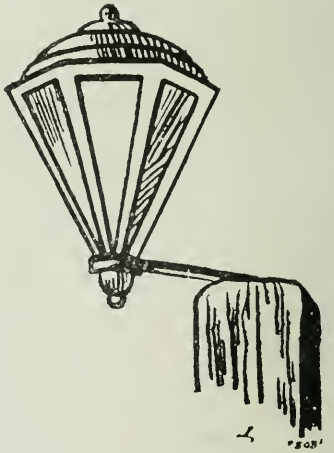


FIG. 12.—Old street lantern.

so well was it carried out that it is stated that no fewer than "72,000 persons were hanged in his reign."[13a]

13a 'Sermons in Candles,' Lond., 1891, p. 42.

In an article by Mr. Fred W. Burgess in 1907, which he illustrates by some good specimens of burners and old lamps in use in old London, he says: "London has been lighted by almost every form of illuminant from candles to ropes soaked in pitch to the glare of the present day. It is somewhat curious that there should be no trustworthy evidence of any illumination at night of the cities of ancient Greece and Rome. Save on exceptional circumstances of public rejoicing the resources of ancient civilization seemed to have exhausted themselves at nightfall." The article was accompanied by illustrations of old forms of rushlight holders,[13b] (Fig. 10) the burning cresset carried by the watchman on his shoulder (Fig. 11); also the early forms of gas lamps introduced in London in the early part of last century, fixed on wooden posts (Fig. 12); and some very ornate torch-extinguishers, still found fastened to the iron railings around the West-End mansions. (Fig. 12a.)

(There are three of these old cressets still in use in the chapel of the Pyx in Westminster Abbey. There is also one in the Tower of London among the Armoury.)

In 'The Lights o' London,' an article published in *The News*, January 18th, 1907, we are told that "cressets were carried by some of the Watch, and were also used to some extent as stationary lights. They were vessels resembling cages, or iron caps of open work, turned upside down and fixed at the top of a pole, which was provided with projecting pieces of wood at each side. By these projections the man who trimmed and lit the light was accustomed to ascend and descend. The light was obtained from combustibles burning in a hollow pan at the bottom of the cresset, or from twisted rope, making a rough kind of wick, soaked in a melted mixture of pitch, tallow, linseed oil, hard resin, and turpentine."[14]

Lighting, both for public and for private purposes, as reviewed, has been, and will ever be, a highly controversial subject. In fact, it has been so ever since the time of the curfew, or when

FIG. 12b.—Old lantern and torch extinguisher in Berkeley Square, London.

FIG. 12c.—One of the very earliest gas street lanterns, in a court near Newgate (London). *(Removed for the purpose of the Lecture.)*

the citizen was compelled to light that portion of the street which was outside

13b 'The Lights of Old London,' by Fred. W. Burgess (*The City Press*, London, Aug. 10, 1907).
14 *The News*, Charles Murray, Ludgate Square, London, 1907.

his own house by exhibiting a "lanthorn" over his door, between the hours of sunset and midnight, on certain nights of the year, defined in the calendar by the Festivals of Saints whose natal days occurred in that period of the year, which was of the darkest. When a man should go to bed, and how much he should contribute to the common weal in oil or tallow for the benefit of those whose business or pleasure kept them out of their houses after sunset—these were matters which in those early days continually agitated the public mind.

Early Burners.

From the *Philosophical Transactions* of 1739, it appears that Dean Clayton, of Kildare,[14a] had been experimenting with coal-gas, with a view to saving some of the "spirit," took a receiver, and "putting a candle to the pipe of this vessel whilst the 'spirit' arose, it caught flame, and continued burning at the end of the pipe, though you could not discern what fed the flame" when he blew out and lighted several times.

Murdoch, when working at Redruth, Cornwall, in 1792, used a bladder with a pipe fixed in its neck terminating in a small jet. He forced the gas out by keeping the bladder under his arm and squeezing it, after the manner of "bagpipes." He thus lighted his way home and to his work, to the terror of the countryside.

Fig. 13.—Early "Cockspur" and "Cockscomb" burners.

The burners in use were the cockspur, cockscomb, batswing, rat-tail, and argand. The first named seemed to have consisted of a hollow globe about $1\frac{1}{2}$ in. in diameter, pierced laterally with from three to five holes of about one-thirtieth inch diameter. Out of these flames issued in straight jets. Naturally, the combustion was not perfect, and it was also a wasteful manner of burning gas. The hot-air currents gave the upward tendency to the long, spikey flames, which took the shape of a fleur-de-lys, and also caused them to curve in the form of a spur of a game-cock. The consumption of the cockspur was $3\frac{1}{2}$ cubic feet per hour; that of the batswing being 5 cubic feet. The flame of the rat-tail burner consisted of a long, upward spike. The photograph of the cockscomb and the cockspur burners here reproduced has been lent by Prof. Vivian B. Lewes, who informs the writer that recently, when in Ireland, he saw rat-tail burners still in use.

I was surprised, however, when at Glasgow in 1911, to find that the City Authority had over 45,000 rat-tail jet burners in use in the closes and on the common stairs throughout the City's tenements.

At the beginning of the century, when gas was paid for by burner, not much encouragement was given to consume gas. Here is an example of the Wandsworth Co., I believe :—

1821.

No. 1, Argand, dusk till 9 P.M.	£2 10 0
10 „	2 16 0
Gas at 10*s.* per 1,000 ft. 11 „	3 4 0
All night	4 8 0
If burnt on Sunday one sixth extra ...	
One jet for hall, or passages, 4″ flame	1 10 0

And of the Bodmin Co.* :—

Description of Burner.	From Dusk to—								
Gas 10*s.* per 1,000 feet.	9 o'Clock.			10 o'Clock.			11 o'Clock.		
No.	£	*s.*	*d.*	£	*s.*	*d.*	£	*s.*	*d.*
1. Single Jet	1	0	0	1	4	0	1	8	0
2. Double Jet	1	5	0	1	10	0	1	15	0
3. Treble Jet	1	12	0	1	18	0	2	4	0
4. Batswing	3	10	0	3	17	6	4	5	0
5. Eight-hole Argand	2	2	0	2	9	6	2	17	6
6. Twelve-hole Argand	2	15	0	3	2	6	3	10	0
7. Sixteen-hole Argand	3	10	0	3	17	6	4	5	0

One hour extra allowed on Saturday nights.

* From *Gas World*, 1907.

14a.—See also *Transactions* of the Royal Society, 1739, vol. xli. (Paper by Dr. Clayton, Dean of Kildare).

A reduction on £2 2*s*. Lights, and above, of 2*s*. each, on taking four Lights, and upwards.

An addition of one-sixth for Gas consumed on Sundays.

CONDITIONS.

1. The Company will convey the Gas to the fronts of the Houses, in those Streets through which the mains are carried; all connections to which are to be at the expense of the consumer.
2. Payments to be made quarterly, in advance, as follows: the Lady-day and Midsummer Quarters to be one-eighth, and the Michaelmas and Christmas Quarters three-eighths of the annual charge.*
3. Any person, who may be found using the Gas after the hour contracted for, will be charged up to the following hour for that Quarter.
4. Persons desirous of using Gas at any hour not specified in the above list, or any Burner not mentioned, may do so on contracting for the same.
5. The flame is not to exceed five inches in height.
6. No burner or Fittings of any kind to be used but those approved by the Company.

* Example. An eight-hole Burner to 9 o'Clock, annual charge £2 2*s*., Lady-day and Midsummer Quarters 5*s*. 3*d*. each, and for the Michaelmas and each.

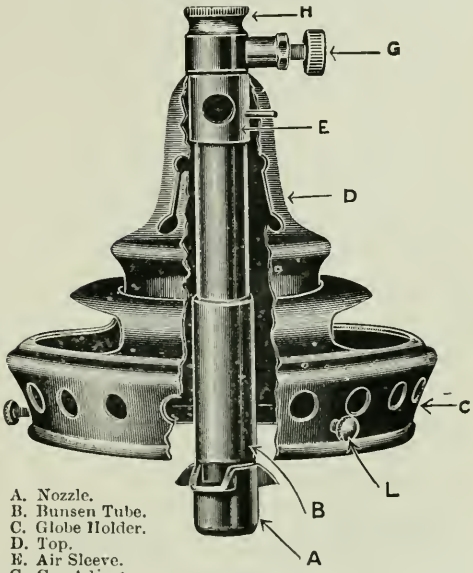
Liddell & Son, Printers, Bodmin.

[*Some words are apparently missing from the original.*]

In December, 1813, Westminster Bridge was first lighted by gas; and the year after the oil-lamps were removed from the streets of the parish of St. Margaret's, Westminster, in favour of gas-lights. But so strong was working-class opposition to the new invention that Clegg was obliged to light the lamps himself for the first few nights, the lamplighters stubbornly refusing to do so. In 1815 the Guildhall was lighted by gas, and the public press teemed with the most extravagant praise of it—"as shedding a brightness clear as summer's noon, but undazzling and soft as moonlight, though forming a magnificent combination worthy the inauguration of the presiding citizen." The year 1816 found a large part of the Metropolis illuminated by gas, more than 4,000 argand burners having been put up, while arrangements were being made for a large extension.

The names of George Bray and William Sugg occur directly we begin to speak of burners.

Mr. Bray was born in Leeds in 1841. In his youth he became attached to the woollen industry, in which his father was engaged. The work, however, was distasteful to him, for he was of a mechanical turn of mind, and his evenings were devoted to self-improvement at the Mechanics' Institute. While attending the classes there, in 1863, he conceived the idea of improving the old iron gas-burner, so as to enable it to give a better and more steady light. Two years later, when he was twenty-four years of age, he took out his first burner patent. His early efforts were not altogether successful; but he persevered in his experiments, and eventually produced the burner with a non-corrosive tip



A. Nozzle.
B. Bunsen Tube.
C. Globe Holder.
D. Top.
E. Air Sleeve.
G. Gas Adjuster.
H. Nipple
(*a*) Adjuster.
(*p*) Plain.
L. Globe Screws.

FIG. 14.—Section of a Bray "'09" inverted burner with patent gas adjuster.

which has been so largely adopted. The making of gas-burners became such an important part of his work that he resolved to devote himself entirely to it; and about the year 1872 he took a small factory in Blackman Lane, and soon found himself in the full tide of business. An efficient flat-flame burner which could be bought at a price that would bring it within the reach of all classes of consumers was much wanted, and Mr. Bray's ingenuity and perseverance furnished it. The production of the porcelain tip burner was for a long time the main

feature of the business; but in 1878 or 1879 Mr. Bray turned his attention to the improvement of the lamp in which the burner was to work. The result was the production of a lantern in which, in place of the old square glass case, one was used which tapered downwards, so as to avoid throwing a shadow upon the ground in the immediate vicinity of the post. The illuminating power of the gas-jet was also increased by placing reflectors in the roof. These lamps have become as familiar as the name of the inventor. Ample evidence of Mr. Bray's inventiveness is afforded by the Register of Patents. Between 1872 and 1903 he took out numerous patents for improvements he had effected in gas-burners, street lamps, &c.

His first burner was brought out in 1865. The names of some of them are: the "Cockspur," "Heron," "Iron Batswing," "Brönner," "Iron Union Jet," "Metal Slit Union," and "Steatite Union," followed by the equally well-known "Regulator," "Market," and "Standard" burners, and the special "Gas Economisers." George Bray was taken away from his labours in 1905, at the age of 63. The firm is still actively engaged in up-to-date lighting.

Mr. William Sugg's career was equally interesting. In March, 1867, a pamphlet issued by Dr. Letheby, on the illuminating power of the Metropolitan gas, made the first mention of the late Mr. William Sugg, viz., "The burners having been the fifteen-hole steatite argand of Mr. Sugg, which, with a consumption of 5 ft. of gas per hour, and with a 7-in. chimney, gives about 11 per cent more light than the old brass burner."

In June, 1869, a statement was issued to the Metropolitan Board of Works by Mr. T. W. Keates, F.C.S. In this reference is made to Sugg's "new argand burner." "By this burner the lighting power of common gas is raised, according to report, in the proportion of 100 to 116. As, however, an argand burner of this description is not suitable for ordinary use, and the fishtail is for several reasons likely to be retained as the common burner for the public, I submit it is not fair to the consumers that such a new burner as the new argand burner should be used as a standard, unless they were generally enabled to avail themselves of its advantages. As it is, they must be content with the fishtail, which, even of the best construction, gives only 89 per cent. of the light of the old argand. Compared with the new argand, the light given by the fishtail burner is only 89 out of 116. The fact is that, by the alteration of the standard, the gas gains 16 per cent., leaving the consumer no better off than he was before. The effect will be that the examiner will be obliged to report 16 or 14 as the photometer value, while 14 or 12 candles respectively will be what the public will get."

Mr. Sugg has been so recently taken

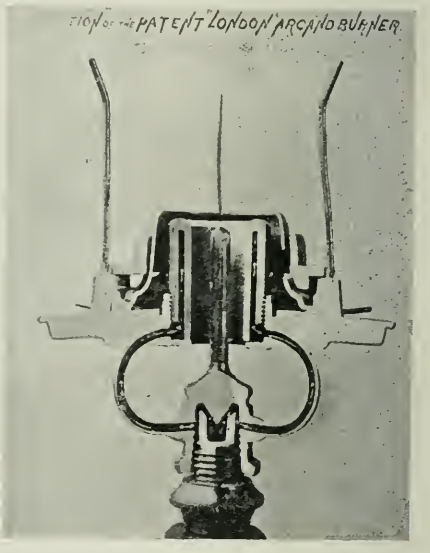


FIG. 15.—"London" Argand burner.

from you that the memories of his life and work are still with most of you. Was it not in those exciting days of the "early sixties" that William Sugg was the assistant in the learned Dr. Letheby's demonstrations, and "was it not his deft fingers that arranged the brilliant experiments that delighted the Gas Managers of those days."[15] With what zest would he have thrown himself into this evening's work! How crowded would have been

15 Thomas Newbigging's History. Lond., 1901, p. 44.

this hall with models, burners, and diagrammatic charts could I have but sought his aid. Whenever I visited him to seek his counsel and advice, I always found him more than willing. His office was half-laboratory, half-workshop, crowded with working models and parts of burners, &c. In the year that Queen Victoria came to the throne (1837) the firm of Sugg & Co. commenced in Westminster; and when, in the late "fifties," William Sugg took upon himself the burden of the whole business, his motto was, first, "Experiment"; secondly, "Experiment"; and, thirdly, "Experiment." If, then, he had not reached a conclusion satisfactory to himself, he still continued experimenting. To know the history of William Sugg would entail the reading of all the principal Gas Acts of private companies and municipalities throughout the United Kingdom and on the Continent, as well as of the Colonies and the United States; and the name of Sugg, in connexion with the gas industry, will go down to posterity with names like those of Clegg and Livesey. William Sugg was, perhaps, best known in the Committee-rooms of the Houses of Parliament. When their occupants were engaged upon the discussion of difficult and scientific questions in connexion with Private Bills relating to gas legislature, he would be sent for, and would afterwards be found either in the witnesses' chair or collaborating with other eminent engineers upon the details of obscure problems. William Sugg was, firstly and pre-eminently, a scientist and engineer, and a personal acquaintanceship of many years caused him (the author) to mourn his loss and pay this tribute to his memory.

A mere mention of a few of his best-known burners, all giving good duties, will give an idea of his grip of this subject: the "Standard," "Christiana," "Argand" (for indoors), the "Billingsgate" (a large multiple burner in use at the markets), the "Strand," the "Lambeth" (for street lighting), the "Northumberland Avenue," the "Multiple" (for refuges), the experimental burners used on the Holborn Viaduct, the Poultry, Moorgate Street, and Waterloo Road—with the exception of the Argand, all these were flat-flame. When the occasion arose, Mr. Sugg turned his attention to incandescent burners, and was equally successful. The following is a chronological list of some of his best-known types of burners:—

Hollow Top Steatite Burner ..	1868
Improved Hollow Top Steatite Burner (circular slit)	1874
Table Top Steatite Burner ..	1884
Cone Top ,, ,, ..	1897
Small Governor Burner	1880
Triple Billingsgate Burner ..	1880
10-Flame Combination Burner ..	1880
Christiania Governor Burner (Italian pattern)	1874
Bicurrent London Argand (Burner No. 1)	1868
Tricurrent London Argand Burner	1874
Long Body "D" Argand Governor Burner	1894
Frankfort Argand Burner, with eye-screen and shade	1876
50c. Argand Burner	1879
100c. ,, ,, ...	1879
Vincent Lamp	1883
Cromartie Regenerative Burner	1884
High-Pressure Vertical Incandescent Burner	1899
Pressure Increaser	1898
Low-Pressure Christiania Incandescent Burner	1899
Low-Pressure Inverted Incandescent Burner (N.E.R. pattern)	1907
Do. (1953 pattern)	1907
Do. (Regent pattern) ..	1908

The firm have adapted themselves to the altered conditions, and are keeping pace with modern inverted incandescent and semi-indirect burners.

In July and November, 1861, Col. Haywood made two very interesting reports on the 'Carburation of Gas, as Supplied to the Public Gas-Lamps by the Process of the United Kingdom Carburating Gas Company.' This was a patent for placing near to the gas-burners a receptacle containing coal naphtha, the gas passing through or over this, taking up, and becoming enriched by, the additions of the volatile hydrocarbons contained in the naphtha; the illuminating power of the gas being increased from 25 to 77 per

cent, according to the quality of the naphtha. The inventors claimed that equal light would be given with half the quantity of gas. It was stated that the naphthalization of gas would effect a saving on each public lamp of £1 per annum.

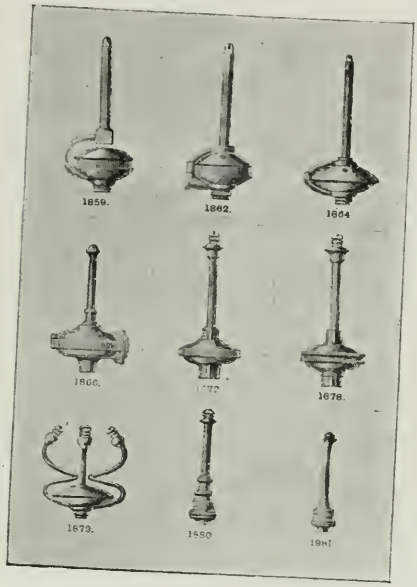


FIG. 16.—Chronological chart of lamp cock governors (Sugg's 1859-1881).

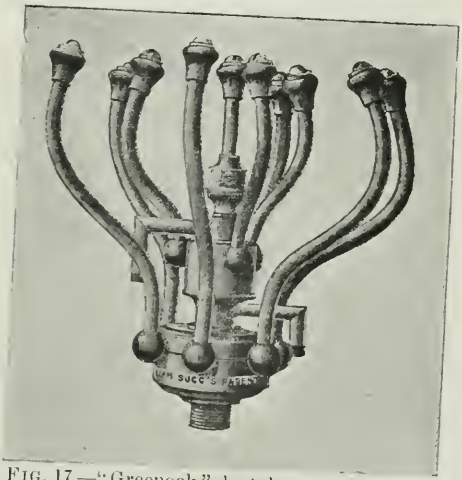


FIG. 17.—"Greenock" dock lamp combination. One burner alight only after midnight.

EARLY EXPERIMENTS IN STREET-LIGHTING.

In December, 1862, the companies not agreeing, Col. Haywood, Engineer to the Corporation of London, in conjunction with Dr. Letheby and Mr. George Hughes, a well-known gas engineer, suggested fixing meters to public lamps and charging for the

FIG. 18.—"Lambeth" multiple burner lamp, 1879.

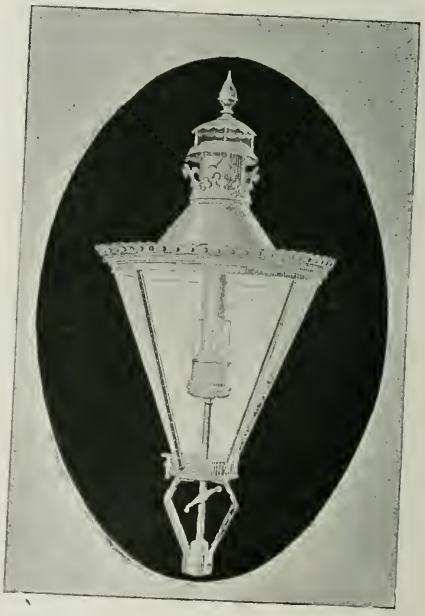


FIG. 19.—200 candlepower Argand burner in street lamp.

amount of gas consumed; and Mr. Hughes estimated that 30 per cent less gas was given than was paid for. He calculated that so much less gas appeared to be furnished by the companies supplying Westminster, that over £2,021 was being paid annually above the proper amount.[16] It was instanced that gas was allowed to be supplied by meter to the public lamps at Leeds, Leicester, Lincoln, St. Ives, Worthing, Torquay, and other places, and that it was universal in Scotland. The same year another lengthy pamphlet on the carburating or naphthalizing of gas to the public lamps was published.

During the past few months much has been said and written with regard to the now well-established forward policy of the premier gas company in the Metropolis, which is this year celebrating its centenary. In connexion therewith the honoured name of the Governor of the Company, Sir Corbet Woodall, has been freely mentioned as the one chiefly responsible for this policy, and that the date of his advent to the office of governor synchronized with its commencement. Though this is quite true with regard to the date when the Company, with their new head, started on their active campaign, both within and outside the

FIG. 20.—Artistic refuge standard in Trafalgar Square, with flat flame burners (now lighted with high-pressure gas).

FIG. 21.—"Chromartie" regenerative burner (cluster lamp).

Many experiments went on in the public streets with burners of various kinds now that the industry was put upon its mettle by its keen competitor Electricity; *e.g.* the experiments by Sugg's new Multiple burner (see Fig 18). These were carried out in various parts of the City of London and in the provinces; one very interesting experiment was, for instance, carried out in the Waterloo Road in 1879.

administrative Board Room, it is far from being so with regard to the author of the policy himself. Sir Corbet Woodall, who, more than a quarter of a century (to be correct, twenty-seven years) previous to his election to this high administrative office, was then in the very midst of the fighting arena, waging the battle of gas lights against the then newly introduced illuminant, at which time a great deal of energy and ingenuity were displayed in conducting the interesting controversy on the respective merits of gas *versus* electricity. *The Daily News* of January,

16 This was borne out also by Mr. Arntz, the Surveyor to the Local Board of Westminster, who made an investigation, in the year 1858, into the quantity of gas supplied by the three companies lighting that district.

1879, speaking in regard to this as "a gas-retort," said :—

"It has at length occurred to a gas company to give a practical illustration of what gas can do if it be fairly dealt with. The promoters of the electric light have recommended it to the public by the simple expedient of displaying its powers in the public thoroughfares, and for some months they have had it all their own way, mocking the puny gas-lamp lights in the Strand, on the Embankment, and on Holborn Viaduct with globes of glorious light. After a period of apparent paralysis, the gas companies are beginning to take courage. There is no question of the superior brilliancy of the electric light as applied to street illumination. But behind looms the question of cost ; and the dark shadow of the ratepayer is a deterrent influence on street illumination," &c.

"Under the direction of Mr. Corbet Woodall, the accomplished Engineer to the Phœnix Gas Company, with whom the experiments originated, these lamp-posts were removed, and 48 new ones set up—of course, at closer distances. The new lamp-posts differ from the old ones in many important particulars. In the first place, they are 2 feet shorter—a hopeful recognition on the part of gas companies that it is the street pavement that wants lighting, not the first-floor rooms of the adjacent premises. The lanterns are crowned with opal glass,[17] which reflects downward a greatly increased proportion of the light.

"The retort courteous of the Phœnix Gas Company to the brilliant arguments of the electric light seems to prove that the gas companies can light the streets if the public will consent to pay for the luxury."

In the article were many figures and tables giving comparisons between the cost of the two illuminants which were greatly to the advantage of the gas lighting. Now history repeats itself, in this case by the same individual, who, after thirty-three years, is still spared to you. In this experiment credit must be given to Mr. Sugg, who was also interested in, and largely responsible for, the ultimate success of the installation mentioned, he being the inventor and maker of the gas lanterns used, and the steatite burner specially designed for the experiment.

I am also reminded of this fact by one who remembers the circumstance, and who says : "You quote from *The Daily News*, but why leave out *Punch*, who said on the 15th of February, 1879 : 'The real modern Aladdin's magician is Mr. Sugg, who, by means of his improved burner, gives us "new lamps for old ones." See the Waterloo Road and Waterloo Place *passim*. "*O si sic omnia*"? If all gas-light were like these, who would ask for Edison and electricity ?'"

The Beginning of Public Lighting by Electricity.

In the year 1878 these experiments continued. Mr. Deputy Bassingham and Col. Haywood, the then City Engineer, reported to the Streets Committee of the Corporation of London on the Jablochkoff lamps (a French syndicate) installed in the Avenue de l'Opéra, Paris.

The early lighting of Holborn Viaduct (November, 1878) by sixteen Jablochkoff lamps, displacing eighty-six gas lamps, may be looked upon as the initial step which ultimately culminated in the present arc lighting of the City ; but, as is well known, this experiment was not a financial success. It is interesting to note that a lamplighter was present each evening, from sunset to midnight, of the three months the experiment was running, to light up the gas-lamps when the electricity failed, and that his services were necessary. After three months' trial, it was found that the sixteen lamps cost £10 per night, against £1 7*s*. 1½*d*. for gas, or 10*s*. 7*d*. per lamp per hour, while the cost of a gas-lamp was but 0·27*d*., or little more than ¼*d*. Taking the charge per annum, electricity cost £3,072 against £419 for gas for this small area ; and as the former light came to about 7½ times the cost of gas the experiment was abandoned.

In 1879 the electric light was introduced into Billingsgate Market in the

17 This was the first time that opalescent glass was used in the roofs of gas lanterns.

City of London. In 1880 the City Commissioners again decided to experiment, Ludgate Hill, Cheapside, and King William Street being lighted by the Brush Company, the Electric Light & Power Generator Co., and Messrs. Siemens, the contracts being for one year, which ended in April, 1882. Of these, the lighting by the Brush Company proved commercially successful. Further experiments by the Brush Company followed, while the Ediswan Company made a demonstration in Holborn Viaduct with ninety-two 16 c.-p. glow lamps, installed in place of eighty-six batswing gas burners.

Owing to the passing of the Electric Lighting Act of 1882, matters were held in abeyance while the Commissioners considered the position in which the Act placed them. In 1882 Sir W. H. Preece was consulted, and thenceforth made exhaustive reports on the question of the public lighting of the City.

The first practical electric lighting of the City streets on a large scale, however, may be said to date from the Brush Company's proposal of 1885, the conditions of which were practically those adopted by the Commissioners in 1889. After thirteen years of deliberation and experimental trials, 1890–91 saw the Brush Company and the Laing, Wharton & Down Co. obtaining definite contracts and provisional orders within the City. These contracts required that the lighting of the main thoroughfares by arc lamps should be completed by the end of 1893.

Strange as it may seem, with electric light coming along in 1889, oil being cheap, an experiment in lighting Holborn with petroleum oil was carried out by the Defries Safety Lamp and Oil Co. The experiment lasted for a year; but nothing practical came of it.

A very interesting article appeared in one of the trade journals about this time (1891), entitled 'The Modern Slaves of the Lamp,' in which the new lighting was blamed for late shopping and consequently later hours of work for shop assistants, and an agitation was raised against the same by certain trade journals.

Twenty-one years ago (in 1892) some 409 "open" type arc lamps were installed in the City of London main streets, necessitating the extinguishing of 1,126 gas lamps.

Shortly before this (in 1891), on the introduction of electric light into the City of London, *The Daily Telegraph* had a long leader on the subject, remarking "The 'Lord Mayor's Show' will be made visible to the naked eye, despite the worst that a 'London particular' can do to blot it out from human ken."

Introduction of the Welsbach Mantle.

Following the introduction of the Welsbach burner for street lighting in 1895, in the Metropolis by the Borough of Kensington, and South Metropolitan Gas. Co. on the Surrey side of the Thames (the Gas Light & Coke Co. would not touch it at that date, on account of the fragility of the mantle), I made a very exhaustive experiment and many observations, choosing Wood Street, Cheapside, a thoroughfare about 450 yds. in length. The experiment was commenced in May, 1896.

Previous to the incandescent burners being used, I had them fitted with "Goodson's" governors, and tested at various pressures (this for the Gas Co.'s satisfaction as well as my own), with the following results:—

Results of Testing Incandescent Burners with "Goodson's" Governors.

	Pressure 10/10ths	15/10ths	20/10ths	25/10ths	30/10ths
	Consumption 3·60ft.	3·60ft.	3·60 t.	3·60 t.	3.60ft.

3·7 was the consumption, with about one-tenth foot for the flashlight. I then had them tested (through the kindness of Prof. Vivian B. Lewes) on the Dibden radial photometer, to get the effective lighting value at the working angle of 45 degs. below the horizontal line, also on the horizontal line, and at various angles between 45 degs. above and below it, with the results as set forth.

INCANDESCENT BURNER WITH REFLECTING CHIMNEY, ETC. TESTS ON RADIAL PHOTOMETER AT 1 IN. PRESSURE.

Position	Gas Consumption cubic ft. per hour	Light in Standard Candles
45°	3·7 c. ft.	22·0
40°	"	26·0
35°	"	30·0
30°	"	34·0
25°	"	36·0
20°	"	40·0
15°	"	44·0
10°	"	48·0
5°	"	50·0
Horizontal	"	50·0
5°	"	46·0
10°	"	42·0
15°	"	40·0
20°	"	38·0
25°	"	35·0
30°	"	32·0
35°	"	28·0
40°	"	22·0
45°	"	18·0

This gave a value of 50 c.-p. on an horizontal plane, and an effective value of 18 c.-p. at an angle of 45 degs. below.

(*N.B.*—As the burners were afterwards fitted into lanterns with porcelain reflecting cones to catch the upward rays, the results would be much higher than shown in table.)

Then, to get a comparative value of the Welsbach burner with the ordinary 5-ft. governor burner then in use, I had two specimens, by different makers, similarly tested, when they gave the following readings. (See next table.)

No. 1 burner gave a slightly lower reading than No. 2, but the mean of the two readings gave the candle-power on the horizontal as 11 candles, while at 45 degs. below a mean value of 8½ candles, where the light was most wanted. The loss in effective candle-power below the horizontal was most pronounced in the early Welsbach burner, viz., no less than 32 candles; the common flat-flame burners only lost 2½ candles when at 45 degs. below the horizontal.

STREET LAMP GOVERNOR BURNERS.

No. 1. "Borradaile."		No. 2. "Sugg."	
	Gas rate 5 c. ft. per hour. Pressure 1 in.		
Position	Candle-Power	Position	C.-P.
45° above	9·0	45° above	10·6
40°	9·2	40°	10·8
35°	9·4	35°	11·0
30°	9·6	30°	11·0
25°	10·0	25°	11·0
20°	10·2	20°	11·0
15°	10·4	15°	11·2
10°	10·4	10°	11·4
5°	10·6	5°	11·5
Horizontal	10·6	Horizontal	11·6
5° below	10·6	5°	11·6
10°	10·6	10°	11·8
15°	10·3	15°	11·4
20°	10·0	20°	11·2
25°	9·7	25°	10·9
30°	9·4	30°	10·4
35°	9·0	35°	10·0
40°	8·6	40°	9·5
45°	8·0	45°	9·0

Duration of Experiment.—The lamps were lighted on May 15th, and were in lighting a little over six months, which gave me a good data, viz., half a year, on which to base the following figures.

Gas Consumed.—At 4 cubic feet per hour, as agreed by the Gas Co., and on which the charge was to be made, there should have been consumed 134,402 cubic feet between June 1st and December 1st, 1896, whilst I find by the average readings of the meters I fixed to the services that the consumption was 163,370 cubic feet, or 28,968 more than charged for by the Company, being an average of 4·86 cubic feet per hour. This increase was partly owing to the fact of one or two small leaks on the fittings, and that the "pilot" lights were going during the whole twenty-four hours, whilst the Gas Co. only charged for it during the lighting hours.

Number of Mantles Used.—The number of mantles consumed during the half-year was 106, being at the rate of 6·23 per lamp for the half-year, or

12·46 per lamp per annum, as set out in the following table :—

Mantles per Lamp.			Hours of Lighting 1862.	
By 27 Wood Street	3	Bracket		
„ 33 „	3	„		
„ St. Alban's Church	22	Column		
„ 40 Wood Street	2	Bracket		
„ 56 „	6	„		
„ 48 „	3	„		Average life
„ 66 „	2	„		
„ 74 „	4	„		of mantles
„ 82 „	5	„		
„ 94 „	9	„		
„ 103 „	1	„	180 days or 1,701 hours	29·50 days or
„ Huggin Lane	5	„		
„ 122 Wood Street	4	„		298·62 hours.
„ 6 „	1	„	171 days	
„ 13 „	28	Column		
„ 130 „	2	Bracket		
„ St. Peter's Church Yard	6	„		
	106 ×17=6·23 per lamp for 6 months, or 12·46 per annum.			

It will be seen that the life of the mantles was from 1 day on a column to 180 days on a bracket. There were only two columns in this street, otherwise the consumption of the fifteen brackets would have been 56 (about half the number).

The cause of the breakage of the mantles on the columns was due to the fact that the railway carmen throw the packing-cases off their vans on to the bases of the columns, and these columns had no anti-concussion springs fixed to them to break vertical shocks. Since the experiment had been in existence an anti-vibration spring had been brought out, which reduced breakage of mantles by shock to a minimum. It must also be remembered that there are very few columns in the minor streets of the City of London.

Cost of Gas and Maintenance (Incandescent).

	£	s.	d.
17 lamps at £1 10s. each	25	10	0
Cost of gas at 4 ft. per lighting hour under agreement with the Gas Light & Coke Co. = 292,400 c. ft. of gas per annum, at 2s. 3d. per 1,000 ft. ...	32	17	10
Cost of 212 mantles at 1s. 3d. each ...	13	5	0
Gas fitters time: 74 hrs. at 10d. per hr.	3	1	8
	£74	14	6

Cost of Ordinary Lighting.—The cost of lighting this street by the ordinary 5 ft flat-flame burners with square lanterns was as follows :—

	£	s.	d.
17 5 ft. burners, consuming 21,500 ft. of gas each per annum = 365,000 ft. at 2s. 3d per 1,000	41	2	4
Lighting, extinguishing, and cleaning 17 lamps, per annum	12	15	0
Repairing and maintaining 17 square lanterns, per annum	2	11	0
	£56	8	4

The incandescent lighting therefore showed an additional cost of £18 6s. 2d. for the whole seventeen lamps over the ordinary system ; or, say, £1 1s. a lamp difference ; but against this nearly treble the light was gained.

	£	s.	d.
Cost of ordinary lamp, per annum ...	3	6	4
Cost of Welsbach lamp, per annum, say	4	7	3
difference	£1	0	11

I then tested the burners in Pontifex "Vauxhall" lanterns with reflectors and anti-vibrators, and obtained the following results. (See next page.)

This last test with the "lantern furniture" is interesting, and may have some bearing on the interesting discussion recently raised by Mr. George Helps, C.E. of Nuneaton, entitled 'The Candle and the Lamp.'

The following are the conclusions I came to at that date : "That this form of street lighting is most advantageous for minor streets, as the small difference in cost enables the

lanterns to be placed, lamp for lamp, with the existing system, thus evenly distributing the light over the whole of narrow streets and destroys any zones of dark shadows caused by intense centres of light set up at a particular portion only of a street."

Consumption of Gas Cubic feet per Hour.	Angle.	Light Candles.
4·1 c. ft.	Horizontal	40·0
	5° below	40·0
	10° "	40·0
	15° "	35·0
	20° "	35·0
	25° "	35·0
	30° "	31·0
	35° "	30·0
	40° "	29·0
	45° "	27·0

Previous test without Lantern—
50 candles at light source, and 18 candles at 45° below.

Self-Intensified and Regenerative Lamps.

Experiments now followed thick and fast with all kinds of burners capable of being used in connexion with the incandescent mantle.

The "Wenham" regenerative lamp, in 1890–91, was very successful, particularly as an outside shop lamp, and still obtains a certain support. Also the Sieman's regenerative lamp, which came out earlier. Following these, a large number of "regenerative" and "self-intensified" burners for superheating the gas and increasing the flow came upon the market, particularly interesting being the "Scott-Snell" "self-intensifying" lamp.

Scott-Snell was born in 1861 at Salt Marsh, Cornwall, and came of an engineering family, his father becoming —after serving his articles with the great Brunel—a railway engineer in Australia, where he constructed the first railway in the Southern Hemisphere. At this time the Jabachkoff Co. entered into a contract for lighting the Thames Embankment. The Company was not, however, a commercial success, and other systems quickly came to the front. Incandescent electric lighting entered into competition. Edison and Swan took the field, both having strong financial support, and the company that retained Mr. Scott-Snell's services went under. For some time he was, engaged in patenting electric appliances, as the records of the Patent Office show.

It was not long, however, before Mr. Scott-Snell sought new fields; the advent of the Welsbach Co. found him in the employ of the marvellously energetic, but somewhat short-lived, firm of Woodhouse & Rawson. Many will remember how this firm undertook to pioneer the new illuminant. In their service he made numerous experiments in burners, and devised what has proved the basis of all subsequent burners—"a large body" and "a small head."

The mantles at that time were supported on brass props ending in a horizontal curl or ring, the mantles being attached to a platinum wire ring, the ends of which were attached to the brass ring.

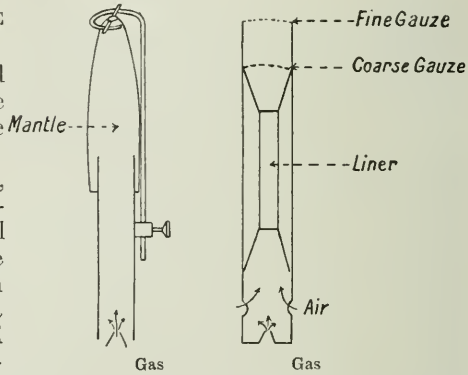


Fig. 22.
(a) Original burner. (b) Original Scott-Snell provisionally protected Welsbach burner.

"The first incandescent mantle factory," says Mr. Scott-Snell, "consisted of a staff of two girls, who worked over tables covered with large plates of sheet-glass for cleanliness' sake, and a pair of 'golden' scissors costing, I believe, something over £6, were provided to cut the fabric. A small domestic wringing machine was used to press the superfluous fluid from the fabric, and the 'fluid' was currently reported to be worth sixpence a drop."

To let Mr. Scott-Snell speak for himself:—

"The public being accustomed to the yellow flame, in many cases

called the new light ghostly, and as the 'mechanical age' had not yet arrived, people were clumsy, and the mantles were inconceivably fragile; in fact, the whole proposition looked anything but promising. At first trials were made of dipping mantles in paraffin-wax, but ultimately collodion was used for transport purposes.

"Even in those days we made efforts to produce inverted burners and mantles, but, of course, unsuccessfully.

"The burner I evolved consisted of a tube about double the area of the original and about two-thirds the length, a much better inspirating effect being produced by placing a liner inside to give a sharp injector effect; and lighting back was prevented by gauze on top, and mixing effected by a somewhat wider mesh gauze placed just over the upper end of the liner. (See Fig. 22.)

"This burner, however, was too efficient, and the mantles of the time were not good enough to stand up to the extra heat, and soon afterwards it looked as if the introduction of the mantle would be a failure. I abandoned the provisional protection, and again found myself in the ranks of electrical engineering.

"In 1899 I was representing the Thames Iron Works at Westminster, and was asked by them to furnish a report on gas *v.* electricity. This brought me in touch with the Hydro-Incandescent Gas Light Co., in which water injectors supplied from the mains drove gas into a reservoir, letting the water flow away through a suitable trap to hold back the gas. The water bill was a prohibitive item, but it showed what could be done by compressing the gas, and it set me thinking. A little logic soon settled the fact that, if power was to be used, there was more than was wanted available in the waste heat from the burner, if means to utilize it could be devised.

"I gave a day to the question, and the next morning filed the provisional specification of what was afterwards known to the gas industry as the Scott-Snell lamp. In tests of various illuminants (electric and gas) made at Westminster this lamp exceeded all others in efficiency, and the then high efficiency of 42 candle-power per cubic foot was also verified in America and on the Continent."

Scott-Snell's lamp depended for its action upon utilizing the waste of products of combustion in heating the air supply conducted to the burner. When the gas burner is lighted, the heat causes the air in the cylinder to

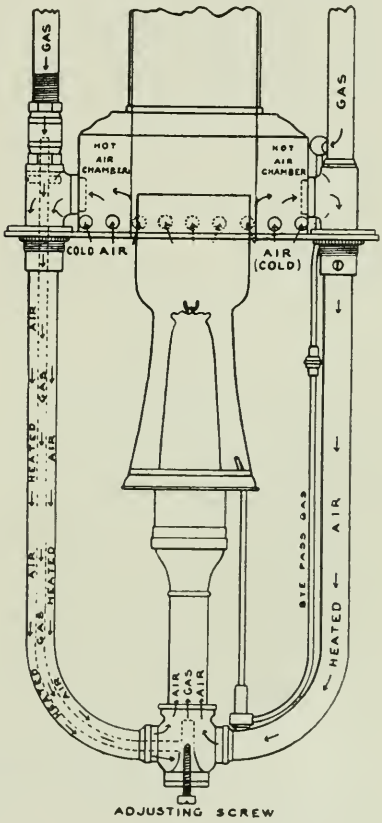


FIG. 23.—The "Podmore" lamp (dust and insect proof).

expand and contract, and brings a displacer into action; the expansion continues until the pressure is sufficient to open the valve communicating with the air reservoir, from whence the heated air, at a pressure of over 1 lb., is conducted through to the burner for combustion. It was claimed that a duty of 40 candles per cubic foot of gas was developed, borne out by the tests of Mr. James Foreman, of Westminster, as set out in a paper read

before the North of England Gas Managers' Association in April, 1906. This was a record until Keith produced his high-pressure pre-heated type. A very good description, with diagrams, is given by Walter Hole,[18] and by W. J. Dibdin[19] and in 'Men we have Known' (*Gas Engineer's Magazine*, 1905). Several of the "Scott-Snell" lamps were in use in the City of London, but later experiments displaced them.

Other self-intensified burners and lamps that came along at this time were the "Moffatt," the "Lucas," the "Welsbach," and the "Podmore." The latter lamp, which is a dust-proof lamp, is largely used in factories and mills where the large quantities of dust and particles in the air choke the air supply to the burner by being sucked in with the feed to the burner nipple. They are also largely used for outside shop lighting and street lighting.

All these lamps led up to the

High-Pressure Incandescent Gas Lighting.

In 1900 the four City bridges were lighted by the South Metropolitan Gas Co. with William Sugg's system of water-driven and gas engine plants. So successful were they on the bridges that the Corporation introduced them into the City thoroughfares, the Streets Committee at that date taking a great interest in the new lighting problems, mainly at the instigation of Mr. Deputy A. C. Morton, M.P., who made a special study of the lighting question, and was for three successive years Chairman of the Committee. Previous to lighting the four City bridges, Messrs. Sugg lighted, as a first London instalment, the "Ship and Turtle" Tavern in Leadenhall Street, in 1898, followed by the lighting of the London Pavilion and the Great Central Railway at Marylebone when that Company came to London. After 1900 they lighted up the front of Buckingham Palace for H.M. Office of Works, then the London, Brighton & South Coast's new railway station at Victoria, the North London railway station at Broad Street, the Bristol Joint Station, Darlington Station, and Tangye's Engineering Works at Birmingham.

The Onslow burner was designed by the late Mr. A. W. Onslow, Engineer of the Royal Arsenal Gas Works, at Woolwich, and was subsequently known as the "Sale-Onslow" high-pressure burner. There were also the "Glover" and "Millenium" high-pressure burners; the latter was the first burner used to light the thoroughfares of Aldwych and Kingsway, a small compressing plant being installed in a cellar by Dane's Inn, near the Law Courts.

The essential feature of this early system was the compressing of the gas before it enters the burners to a pressure capable of supporting a column of water 10 in. high by means of a small hydraulic ram fixed in some convenient position. This ram was actuated by the water from the street mains, and the gas was taken from the services, and the pressure increased as required. The speed of the apparatus and the flow of the water was regulated to the exact requirement by means of a patent governor. The details of this patent are set out in Hole's 'Distribution of Gas,' pp. 606–609.

The next step with regard to high-pressure lighting was the wonderful invention of Keith's,[20] and in 1905 and 1908 several installations were carried out in the City under the present City Engineer, Mr. Frank Sumner, C.E., viz., forty-five upright two-burner lamps were fixed in Queen Victoria Street, each consuming about 20 cubic feet of gas per hour, and giving a light equal to 600 candles. The lamps were fixed upon columns on the footpaths, about 100 ft. apart on the diagonal. The burners were 13 ft. 6 in. above the roadway, the street being about 70 ft. wide. The lamps burned at 10-in. pressure from a high-pressure trunk main direct from the Beckton Gas Works, 42 upright single-burner lamps were also fixed in the neighbourhood of Billingsgate on brackets. These lamps consumed 10 cubic feet of gas per hour, and gave an illuminating value of 300 candles each. They were from 60 to 70 ft.

18 'Distribution of Gas,' pp. 478–82.

19 'Public Lighting by Gas and Electricity' (1902 ed.), pp. 246–60.

20 Hole's 'Distribution,' pp. 609–23.

apart on the diagonal, the height of burner from roadway being about 12 ft., and were fixed upon the house fronts, the roadway being about 50 to 60 ft. wide. The lamps burned at 10-in. pressure from a special water-compressing plant, whilst Fleet Street and Chancery Lane were lighted with the newest developed Keith "inverted" burner, supplied from a special 6-in. high-pressure main connected with a compressor house, the pressure being 54 in. (water-gauge). The lamps were about 103 ft. apart on the diagonal, the height of the burners being 13 ft. to 16 ft., the street being from 45 to 70 ft. wide.

There were other "Keith" and "Sugg's" high-pressure lamps, fitted with upright two, three, four, and six burners, on rests at the junction of roadways, of 1,000, 1,300, 2,000, and 3,000 candles, making 119 in all, in addition to the four City bridges lighted with "Sugg's" high-pressure upright burner lamps, some 135 in number, giving 30 candles to the foot of gas; they were single-burner lamps, with clusters on the centre of the bridges.

Strangely enough, at the very time that the experiment had been deemed by the authorities to be a success as a piece of main road lighting, Sir William Preece, in 1905, true to the opinions he held over twenty years previously, speaking at a meeting of the Carnarvon Harbour Trust, when the proposed installation of the electric light on the promenade was under discussion, strongly urged the Trustees to have the promenade lighted by incandescent gas mantles, which, he said, distributed the light much better than electric lamps. He added that he always recommended public authorities to use them in preference to electricity as an illuminant for public thoroughfares. This well-established fact, and the introduction of the inverted burner for indoor and general domestic lighting as a rival to the incandescent electric lamp, gave a great impetus to the gas industry, and more than helped it to hold its own against its now formidable rival.

The high-pressure "inverted" burner now went forward with great rapidity, both as an illuminant for street and workshop lighting; but it developed in a most remarkable manner for outside shop lighting and "parade lighting," the latter being a scheme by which a number of tradesmen in a busy shopping district would agree to light the whole of the thoroughfare fronting these premises from one compressing plant, the local gas company making the arrangements, giving easy terms, and maintaining them on the principle of "trade following the flag," so it was found by the enterprising tradesmen that "business followed the lamp."

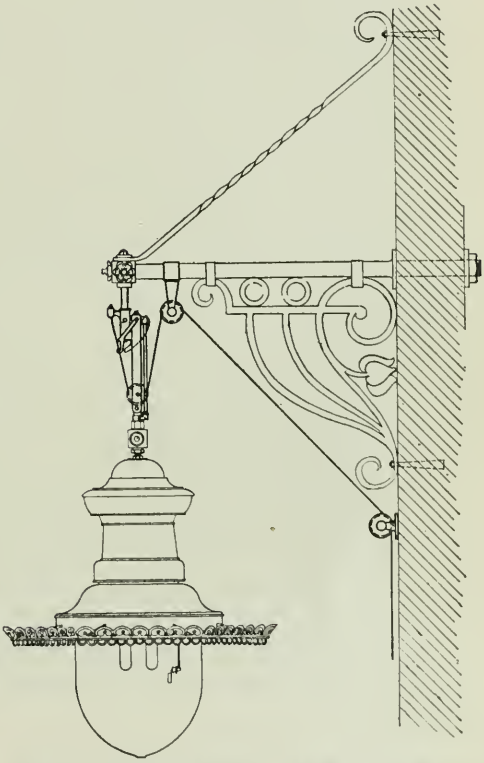


FIG. 24.—Parade Lighting. "Keith" H.P. lamp on bracket with lowering gear.

Ilford, in Essex, was one of the first gas companies to push the system, under their engineer, Mr. W. B. Farquhar. It was also carried out on a very large scale at Hornsey and other places in Middlesex by the Tottenham and Edmonton Gas Co., through the nitiative of their very enterprising engineer, Mr. A. E. Broadberry. The Metropolitan

companies were quick to see the potentialities of this new system of private lighting and the advertisement to be obtained therefrom. Water-driven plants were now hastily discarded, and, with the new burner, came "direct" and "belt" driven plants.

In 1910 high-pressure gas lighting was very largely and effectively used in Berlin, 25 miles of streets being lit by 1,531 lamps fitted with upright and inverted burners, two and three burners in each lantern; they are supplied direct from four separate compressing plants at a pressure of about 53 to 78 in. (water-gauge), the newest type of lamps, viz., the "Graetzin" high-pressure inverted lamp, being fitted with three burners per lantern, giving an illuminating value of over 4,000 "Hefner" candles, two burners being extinguished at midnight.

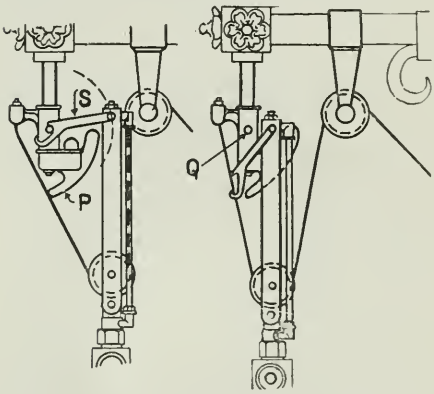


FIG. 24a.—Parade Lighting. Details of lowering gear of "Keith" H.P. lamp bracket.

The distance apart of these high-pressure lamps is from 90 ft. to 100 ft., and the average height of the lamps above the roadway, measured from the burner, about 19 ft.

Gas manufactured by the municipality was of 12 candle-power, *unenriched*, but, tested by the "Metropolitan No. 2" burner, a light equal to 14 or 15 candle-power was obtained—the price of gas was stated to be 1*s.* 4½*d.* per 1,000 cubic feet for public lighting purposes. The calorific value of this gas was 540 B.Th.U., or 135 calories (gross). This compared favourably with the calorific standard for London gas, viz., 14 candles, 500 B.Th.U., or 125 calories (gross), as inserted in the Gas Light & Coke Company's Bill, for Parliament had now seen the wisdom of lowering the candle-power of gas, owing to the need for a non-illuminous flame and the heat required for the incandescent mantle.

Following this, and partly as a result of it, in this year seven centrally hung high-power gas lamps of 1,500 c.-p. (nominal) were installed by the Gas Light & Coke Co. in Cannon Street (at the request of the Corporation of London as an experiment), with gear to lower them to the footway, the winches, &c., fixed in the side-streets where possible. The light is about 26 ft. 6 in. above the centre of the roadway; the lamps are chiefly suspended at the junction of cross-streets. The average distance apart is about 104 ft., the width of the carriage-way about 50 ft.

For the purpose of supplying these lamps, a special 6-in. main was laid in King William Street and Cannon Street, and a compressing plant installed in one of the vaults beneath the northern approach to London Bridge.

The lamps were of the new Keith "inverted" centrally hung type; after the experiment had been running for twelve months the system was approved in November, 1911, by the City, and directions were given to extend the same. This decision to relight the City of London with the most modern form of gas and electric lighting will result in saving about £8,000 per annum out of an annual lighting bill of £21,000; whilst it will double the illumination, which will be distributed in a proper manner, instead of on the fronts of the buildings.

It is hoped to have the whole of the City relighted during the present year of office of the Chairman of the Streets Committee (Mr. G. Gordon Stanham). This year 1913 sees the extension of the new lighting, the Gas Light & Coke Co. laying down steel drawn tubes, 30 ft. in length for the purpose of conveying high-pressure gas.

It is only fitting here to pay tribute to Mr. Charles Carpenter, who had produced a burner for testing gas

which was at last to displace the "old brass burner" and the Sugg argand, both of which had done duty between them for seventy or eighty years. The burner was fully described by Mr. Carpenter in his paper before the Institution of Gas Engineers in 1906, and might be fittingly termed the bringing to a close of one of the chapters in the modern history of gas lighting, so far as testing and public control are concerned, for under the provisions of the London Gas Act, 1905, the Metropolitan No. 2 burner (which is Mr. Carpenter's invention), was adopted by the Metropolitan Gas Referees, and is becoming the prescribed burner for testing gas at a fixed rate of consumption in the modern Gas Acts of the country.

This is only one of the many inventions with which Dr. Carpenter has enriched the gas industry. Sprinkled over the pages of the technical press are records of his many inventions.

In 1909 Dr. Carpenter patented another very interesting burner, which was put upon the market at the end of 1911. It is unique in that it has no shutter for air regulation, so that it cannot be tampered with by unskilled hands. Once set, the light remains constant. With the "straight" gas of the South Metropolitan Gas Co. and their even pressure, the burner is an undoubted success, but so far as pressure is concerned, it has a radius of duty between twenty 10ths and thirty 10ths without affecting the lighting. I have had the

Fig. 25.—Cannon Street Lighting. Centrally hung high-pressure 1,500 c.p. "Keith" lamps.

privilege of seeing the burner in the making, and although there are no

FIG. 25.—The "Metro" burner.

FIG. 25a.—Dr. Chas. Carpenter.

less than sixty-six operations in its manufacture, the finished article is of a very simple character; there being no adjusters, they are simply slipped into a socket and held in position by "bayonet points," somewhat after the manner of the electric lamp. Such a burner had the advantage that it was easy to clean, which in London or large cities, where there is so much dust in the air, is very necessary.

At the present time inverted burners are frequently fitted with both gas and air regulators, in order to adjust them to the special conditions, such

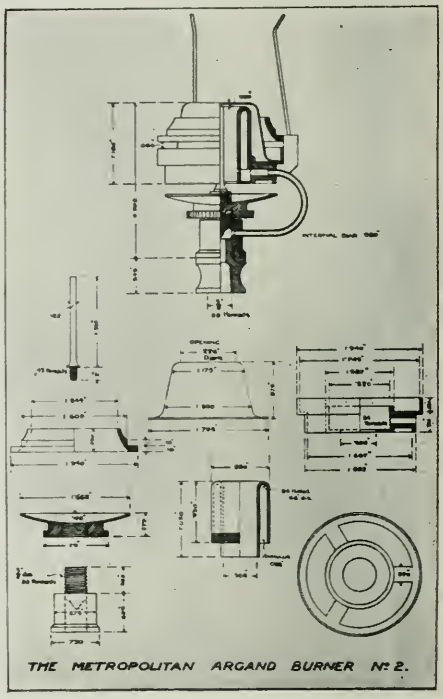


FIG. 26.—Dr. Carpenter's testing burner, "Metropolitan No. 2."

as pressure and composition of the town gas. It seems to me, however, that the type of burner that would give the best result with "mixed gas" and pressures outside the range mentioned should be supplied to consumers, and I believe the "Metro," when away from its "native home," could be adjusted, or set, to those conditions.

"The Nico" low-pressure inverted burner, which was brought out about this time by the New Inverted Fittings Company, is a burner of very good

duty, and is described in detail in the late edition of Mr. Hole's book. It is with this burner that the side-streets of the City of London are to be lighted, displacing the upright "Kern" burners. The "Nico" low-pressure high-power inverted burner of 1912 calls for attention, as it is becoming a rival to the high-pressure lamp for outside shop window lighting, as there is no compressing plant needed, and a duty is obtained, taking in consideration the reflector, of something approaching the neighbourhood of 40 candles per cubic foot.

FIG. 27.—The City of London pattern (1913) "Nico" low-pressure lamp, to be used in the side-streets.

WORKSHOP AND FACTORY BURNERS.

At a meeting of the Manchester Association of Engineers, held on January 25th this year, Mr. Franklin Thorp, of Manchester, introduced a special burner on a "Universal" fitting, fitted with a special reflector which directed the light on the object to be examined, whilst completely shading the light from the workman's eye; and the fitting allowed the light to be turned to any position required.

The "Bland," "Dacolite," "King," "Gretzin Welsbach," the "Mansfield Pressure" burner (as sent out for the Calcutta contract, designed by Mr. Alfred Mansfield, of Liverpool), and many other very excellent burners too numerous even to mention have been brought upon the market to meet special requirements.

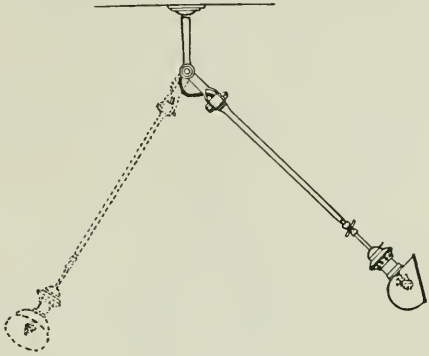


FIG. 28.—Workshop lamp on a universal fitting (Mr. Franklin Thorp).

FIG. 28a.—Rise and fall pendant.

Now, no sooner has a burner a year or two's life, than it becomes obsolete, so quickly does invention follow invention. This has been particularly so with respect to the Keith high-pressure burner; practically every year has seen an advance. Their 1913 lamp, recently patented, has several interesting features. The main one (as all the others seem to arise from it)

"is the enclosure of the mantle in a fused silica globe or cylinder, for a 1,500 c.-p. lamp is little bigger than an ordinary tumbler, it having been found unnecessary to admit secondary air in a well-designed high-pressure inverted street lamp, where the mixture is highly preheated, in order to obtain the necessary incandescence of the mantle."[21] By this method of excluding secondary air, and confining the flame

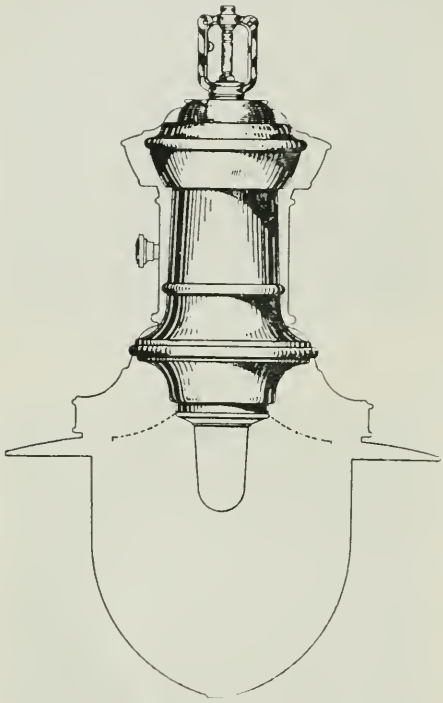


FIG. 29.—The new "Keith" 1,500 candle-power gas lamp (one-sixth scale).

in a smaller area, resulting in a higher flame temperature, it is claimed that at least 10 per cent net increase in efficiency is obtained, after allowing for the greater absorption of light by the silica as compared with glass. The result is a small lamp, as a reflector will no longer be necessary, nor the large and expensive globe, by the abolition of the large globe which form so large an item in maintenance, and the substitution of some other transparent substance for glass, goes a long way to meet Mr. Frank Bailey's wishes for a translucent material in place of the heavy glassware now used in the semi-indirect lighting in so great a demand.

LOW-PRESSURE HIGH-POWER LAMPS.

At the meeting of the Yorkshire Junior Gas Association, held on February 22nd this year, Mr. W. Dawes, of Castleford, giving a paper on this subject, gave an illustration of two very efficient lamps that had been under his notice, viz., the Welsbach "Emperor" and the Welsbach "Pharos." These lamps, with the "Nico" high-power low-pressure and the "Silva" lamp, with others, seem to meet the need of those who do not require a high-pressure system laid down.

UPRIGHT *v.* INVERTED BURNERS.

Quite recently some of the large asylums outside London have been considering the relighting of their institutions, and are hesitating as to what is to be the illuminant. The asylum I have in mind at the moment is lighted by the old "C" upright incandescent burners, and the consumption of gas is 2,000,000 cubic feet per annum. Were all the burners changed to-morrow, and modern inverted burners installed (I am not referring to any particular burner), I am informed that the gas consumption would be halved and the light nearly doubled; if we take the effective illumination value instead of the light source, the increase would be about 50 per cent, as shown by the plottings of the polar curves that have been made and reduced to slides. (Time prevents my showing them to-night.) The moral is: Get rid of all upright expensive gas consumption burners (even if they do bring in heavy gas accounts to the companies), and increase the light at less cost to the consumer by installing the modern economical inverted burner.

I have spoken much about old burners in use in the early days of the industry. I therefore propose to put one or two slides on the sheet showing that the makers are keeping themselves abreast of the times — the semi-indirect lighting with translucent

21 *Journal of Gas Lighting*, Jan. 18th, 1913, p. 451; also *Gas World*, Feb. 22nd, 1913, p. 225.

dishes referred to, and so familiar in all our great banks and insurance offices, and the Holophane scientific glassware. This form of lighting need not be wholly confined to electric light, but can be used in a similar manner with the inverted burner in a semi-indirect form.

Before leaving the incandescent mantle it is of interest to mention the ingenious Robinlyte mantle-making machine. According to this system the cotton or silk is first knitted in lengths of "stocking" and impregnated with rare earth salts, which are then dried in the usual manner. The stockings are then put on the machine and pulled to pieces or unravelled, and the single threads brought together on a mould tied to the correct length for inverted burners, and cut off. The mantle being a collection of loose threads no collodionizing is necessary.

CONCLUSION.

And now a special acknowledgment should be made of my indebtedness to the Technical Press, *i.e.*, the *Journal of Gas Lighting* and the *Gas World* for their assistance, also for the help received from Mr. Thomas Newbigging, Mr. Charles Hunt, Mr. H. E. Jones, the Gas Light & Coke Co., the South Metropolitan Gas Co., the Tottenham and Edmonton Gas Co., as well as to Messrs. Sugg & Co. and Messrs. George Bray & Co., of Leeds, and the various firms in the industry who have added to the interest of the evening by contributing exhibits.

I should like to conclude my remarks by pointing out how much the Illuminating Engineering Society can do for the guidance of those selling and those purchasing illumination. During the last few years many new methods of illumination have been developed. A great variety of methods are at the consumer's disposal, and it is no easy matter to determine *when* and *how* each particular system should be used.

FIG. 30.—The "Keith" H.P. (1913) globeless lamp, High Street, Tottenham, outside the Tottenham and Edmonton Gas Co's Offices.

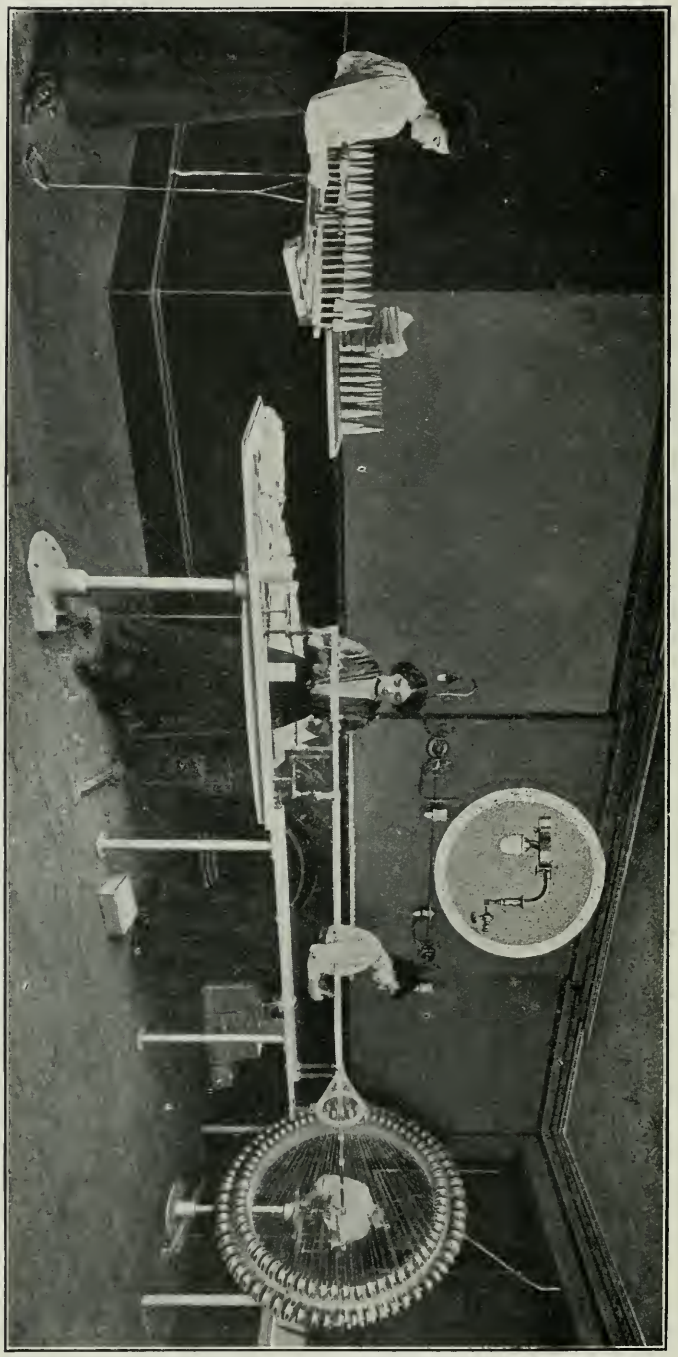
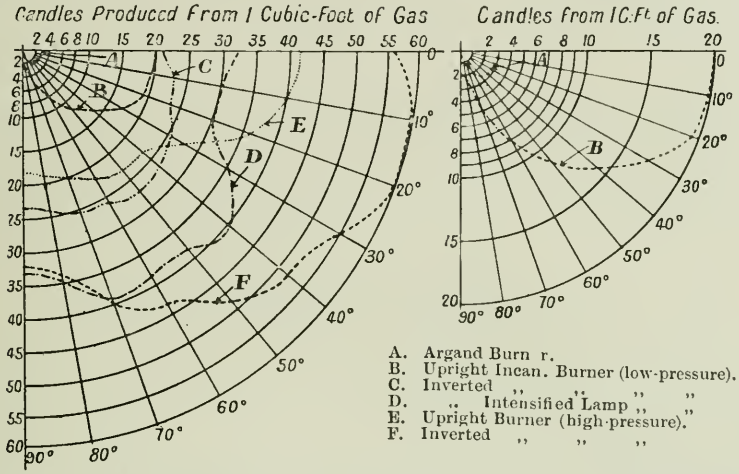


FIG. 33.—The Robinlyte mantle-making machine.

And, as is shown by some of the latest public lighting contracts, viz., the public lighting of Calcutta, Westminster, Holborn—and I might include the arrangement for relighting the City of London—it is not "current," or "gas," or even "light" that is being or about to be purchased, but the effect of light, viz., illumination, and that illumination distributed in a particular manner as set out in the specification—in this case in the street, where it is most needed, quite apart from the light source.

In the same way with regard to indoor lighting, in order to make the best use—and prevent the misuse—of lighting, there is need of guidance which only such a Society as this can give. In the illumination of schools', libraries, shops, and printing works, "Light on the object, not in the eye," should be the motto. The Society's aim is to follow the public taste, whilst guiding it so as to have that avoidance of "Glare," with its accompaniment "Relative Darkness." The customer is now concerned with illumination rather than consumption, and he has to be considered in relation to his need. The manufacturer decides with what he will illuminate his factory, and having settled on gas, he needs advice as to the correct position of the burner with relation to the work to be performed. No longer does he intend to break his neck to suit the burner; no longer is it to be a question on a cash basis, but of scientific illumination.



FIGS. 31 and 31a.—Showing the light obtainable from 1 cubic foot of gas per hour by various methods.

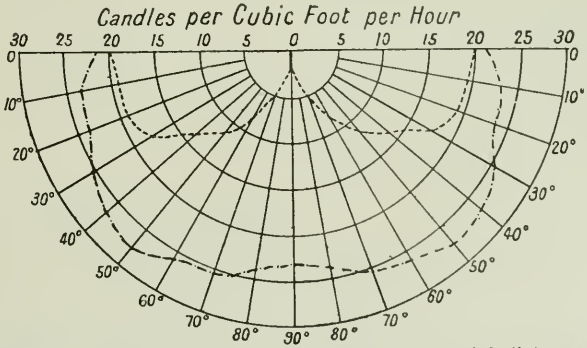


FIG. 32.—Showing the rise in effective illumination from "upright" (upper small curve in diagram) burners to inverted (lower bigger curve in diagram).

Illuminating Engineering Society.

(Founded in London, 1909.)

An Invitation to the Gas Industry.

THE lecture by Mr. W. J. Liberty, reproduced in the previous pages, should serve to show how essential the study of lighting has now become to the gas industry, and there is no doubt that in the future the importance of the subject will be more clearly recognized.

It is probable, therefore, that many of those who have read the lecture will desire to hear more of the work of the Illuminating Engineering Society. Any one who is interested in the aims of the Society is eligible to apply for membership.

We hope that many of those in the gas industry will take this opportunity to do so, for at present the numerical proportion of members interested in gas lighting is not so large as might be desired. Any one wishing to join the Society should fill up the form of application on the opposite page and return it to the Hon. Secretary (Mr. L. Gaster, 32, Victoria Street, S.W.), who will place the name of the candidate before the Council in due course.

The German Illuminating Engineering Society.

THE first meeting of the German Illuminating Engineering Society was held on February 25th, when an address was delivered by the President, Prof. Dr. Warburg (Director of the Physikalische Technische Reichsanstalt).* Dr. Bunte explained the constitution of the Council, of which Geh. Ober-Postrat Dr. Strecker is Chairman, and Dr. E. Liebenthal reported that the Society had already enrolled 211 members. We are glad to see in the list of the first Council the names of many friends who are also corresponding members of our Society. This will doubtless help to promote co-operation between the two societies.

Dr. Warburg, in his address, laid stress on the importance of international agreement on the subject of units and nomenclature used in illuminating engineering, and committees have already been appointed to deal with these subjects. After the official business had been transacted a lecture on 'Illumination and the Eye' was delivered by Prof. Dr. O. Lummer, whose work on this subject is of course well known.

On the occasion of this first meeting a telegram was dispatched to Prof. Warburg expressing the good wishes of the British Illuminating Engineering Society, and received a cordial response. The need for an illuminating engineering society to represent their views and provide for international co-operation is evident, and we shall look forward to the forthcoming meetings of the Society with keen interest.

* *Zeitschrift für Beleuchtungswesen*, Feb. 28th, 1913.

ERRATA.

Our attention has been drawn to two errors that have crept into recent numbers of *The Illuminating Engineer*, and which we now desire to rectify.

The notice relating to the amalgamation of Messrs. Moffats, Ltd., and the British Ross Mantle Concern, which appeared on p. 586 of *The Illuminating Engineer* for December, 1912, should read as follows :—

"The businesses of Messrs. Moffats, Ltd. (of 13, Farringdon Road), and the British Ross mantle concern have been amalgamated under the name of Messrs. Moffat, Ross & Co., Ltd. The new firm has been transferred to larger and more commodious premises at 209, Upper Thames Street, E.C."

The sense of the remarks of Mr. A. Blok in the discussion of the paper by Messrs. Clark and Mackinney (*The Illuminating Engineer*, March, 1913, p. 147) was inadvertently altered by the omission of several words in the last paragraph but one in the first column. The sentence should read as follows: "With Mr. Mackinney's careful methods, there must be behind these curves a vast supply of valuable data, such as mean spherical and hemispherical values, absorption co-efficients, &c., and he hoped that some of these would be put on record."

The Illuminating Engineering Society.

(Founded in London, 1909.)

ANNUAL SUBSCRIPTION, ONE GUINEA.

All Communications should be addressed to :—
L. GASTER, Hon. Sec.,
32, Victoria Street, London, S.W.

Application for Membership.

The members of this Society shall be designated Members, Honorary Members, and Corresponding Members.

A Member may be any one interested in the objects of the Society, but at the date of election shall not be less than twenty-one years of age.

Ordinary, Honorary, and Corresponding Members may be of either sex and of any nationality.

An application for admission to the Society shall be made in a form prescribed by the Council, and shall refer to at least two Members of the Society ; or if an applicant certifies that he is not personally known to two members, references may be accepted to Members of professional societies of good standing, or to other persons whose good standing may be readily verified by the Council. If, in the opinion of the Council, further support for a Member's candidature be considered necessary, the recommendations of four existing Members shall be deemed sufficient ; but the final consideration of a nomination for membership rests with the Council. (*Extract from Constitution*, see *Illuminating Engineer*, Lond., June, 1909, p. 377–382).

We hereby recommend :—

Name .....

Address .....

.....

Occupation, &c. .....

.....

.....

.....

.....

Date and Place of Birth .....

Here state name in full, date and place of birth, rank, profession or business, usual place of residence and qualifications for membership of the candidate.

as a fit and proper person to become a member of the Illuminating Engineering Society.

.....

.....

.....

*Here must follow the names of two or more nominators, one of whom must have personal knowledge of the candidate.

Date .....

Nomination approved by Council .....

Date of Announcement of Nomination .....

Date of Election .....

This portion to be filled up by Council.

The Illuminating Engineering Society.

(Founded in London, 1909.)

Abstracts from Constitution and Bye-Laws.

NATURE AND AIMS OF THE ILLUMINATING ENGINEERING SOCIETY.

The name of this Association shall be the Illuminating Engineering Society.

Its objects shall be the advancement of the theory and practice of illuminating engineering and the dissemination of knowledge relating thereto. Among the means to this end shall be meetings for the presentation and discussion of appropriate papers; the publication as may seem expedient of such papers, of discussions and communications; and through committees, the study of subjects relating to the science and art of illumination, and the publication of reports thereon.

Also the organization of, or participation in periodical national and international exhibitions of developments in illumination, and congresses dealing with the subject.

PUBLICATION OF PROCEEDINGS, &c., OF SOCIETY.

The Illuminating Engineer, published by the Illuminating Engineering Publishing Co., Ltd., in London, shall be the recognized official organ of the Society.

CO-OPERATION WITH OTHER INSTITUTIONS, &c.

The Council shall be at liberty to approach or to entertain and, if desirable, accept overtures from other Societies and Institutions with a view to joint discussions of subjects of mutual interest, exchange of transactions, and co-operation to secure Governmental action, for the advancement of the objects of the Society.

FEES AND SUBSCRIPTIONS.

The annual subscription (one guinea) is payable in advance. Applications for subscriptions shall be sent out quarterly by the Hon. Secretary.

I, the undersigned, desire to become a Member of the Illuminating Engineering Society, and hereby promise that, if elected, I will submit and conform in all respects to, and be governed by, the terms and provisions of the Constitution and the Bye-Laws made in pursuance thereof; provided that whenever I shall signify in writing to the Hon. Secretary that I am desirous of ceasing to be a Member thereof, I shall be free from this obligation, after payment of any Annual Subscription or arrears which may be due from me at that period.

Signature of Candidate.. .....

Date.....

The ILLUMINATING ENGINEER
ELECTRICITY · ACETYLENE · OIL · GAS
Edited by LEON GASTER

THE JOURNAL OF SCIENTIFIC
ILLUMINATION.
OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London, 1909.)

ILLUMINATING ENGINEERING PUBLISHING COMPANY, LTD.
PUBLISHING OFFICES :—ATHENÆUM PRESS 13, BREAM'S BUILDINGS, LONDON, E.C.
Tel. No. 2120 Central.
EDITORIAL OFFICES :—32, VICTORIA STREET, LONDON, S.W.
Tel. No. 5215 Victoria.

EDITORIAL.

The Standard Specification of Street Lighting.

On pp. 241–57 readers will find the paper presented by Mr. Trotter at the last meeting of the Illuminating Engineering Society. We share the general admiration for the masterly way in which Mr. Trotter has dealt with this subject, with which he has been so long identified.

It may be mentioned that Mr. Trotter was invited to read a paper on Street Lighting early in the year, but the date was deferred in the anticipation that the Report of the Joint Committee would be made public later. Events subsequently occurred which led the Joint Committee to regard this as an excellent opportunity of publishing their Report, and of making use of the neutral platform of the Illuminating Engineering Society for an open discussion.

In this number we are publishing the discussion at the meeting of the Society on April 15th, together with the communications received from various authorities on the Continent and in the United States. We propose to print the remainder of the discussion in our next issue, and we shall then take the opportunity of making some further remarks on the subject.

Electric Lighting in the City of London.

The paper on this subject read before the Royal Society of Arts by Mr. Frank Bailey on April 11th contained a most interesting account of the development of electric supply in London. It must have come as a surprise to many people to realize to what proportions the supply of electricity in London has grown during the last ten years; though it still falls far short of some of the great American manufacturing cities.

This development, be it noted, has taken place during a period when the gas companies have also been extending very rapidly. This confirms what was said regarding Mr. Liberty's lecture last month—that there is ample room for both industries to exist side by side.

During the year 1912 approximately 300 million units were supplied in all, and of this *practically half* was used for lighting. It will be seen, therefore, that, contrary to the impression sometimes given, lighting still provides a very substantial source of revenue which cannot be neglected by the electrical supply companies. Moreover, in spite of the introduction of the metallic filament lamp, the supply of energy for lighting has increased very rapidly during the last ten years. We should like to echo Mr. Bailey's remarks as to the importance of scientific illumination to the electrical industry. Encouragement of improved methods of lighting, new units, and the discovery of novel applications of light will be well repaid. In these days each good installation acts as a valuable permanent advertisement which no company can afford to ignore. On the other hand, we would urge on those concerned in the sale and manufacture of incandescent lamps the need for a little caution and foresight in their future policy. It has taken some years for the companies to adjust themselves to the entirely changed conditions brought about by the metallic filament lamp, and it is only reasonable that there should be a little respite before further radical departures are made.

We observe that a sudden reduction has recently been made in the price of Continental lamps. While recognizing the benefit to the industry of cheapening this commodity, we could wish that the efforts of manufacturers were devoted to supplying a better and stronger lamp at the present price, rather than embarking upon indiscriminate price-cutting. Changes such as those we have seen in the last ten years are absolutely essential to the prosperity of the industry. But they should be carried out in a considerate and gradual manner, so that the lamp maker, the supply company, and the consumer may all share in the profit.

Colour Photometry and the Neon Tube.

The physiological peculiarities of the eye met with in the comparison of light of different colours are not usually regarded as being of much commercial importance. Broadly speaking, up to the present time this has been true, and such phenomena have not received much notice, except in the work of Dr. Ives and a few other workers in photometry.

But the introduction of new gaseous illuminants, such as the mercury vapour lamp, the nitrogen and carbon dioxide Moore tubes, and the neon lamp recently devised by M. Claude in France, puts the matter in a somewhat different light. The mercury lamp contains yellow, green, and blue rays, but practically no red. The radiation of the Neon tube, on the other hand, is mainly red and orange. The difficulty of comparing colours so widely different as these is considerable. A striking paper by MM. Broca, Jouast, and Laporte* contains the results of some tests of the Neon tube which suggest that the Purkinje effect can by no means be ignored ; and that differences of 100 per cent between the readings of different observers may readily be produced. Probably the more general use of coloured light for decorative purposes in the near future will bring these problems still more to the front, and they will have to be taken in hand in earnest sooner or later.

On another occasion we should like to say something of the other experiments described by Dr. Broca and his colleagues. It appears that sources giving line spectra, such as the Neon tube, may be favourable to acuteness of vision. On the other hand, the opinion is expressed that it may not be desirable for the eye to be exposed for long periods to monochromatic light, and that some forms of radiation, such as the ultra-violet rays, should be handled with special care—a conclusion which is supported by the experiences of early workers with Röntgen rays.

The Planning of Buildings and the Provision of Artificial Illumination.

The Building Exhibition held at Olympia during the past month afforded an excellent opportunity of bringing the subject of illumination before the notice of architects and builders, who are now coming to regard lighting as a matter of some consequence, to be thought out carefully before the building is completed, and not left to the very last moment. We were also glad to observe that the illumination of the stalls was distinctly better than at many previous exhibitions of the kind.

* 'Bull. Soc. Int. des Electriciens,' Feb., 1913.

An interesting paper read by Mr. H. D. Lanchester, F.R.I.B.A., before the Royal Society of Arts, on April 23rd, aptly illustrated this point. Mr. Lanchester dealt with the design and architectural treatment of shops, pointing out the special structural difficulties created by the necessity of allowing so much space for plate-glass windows. In the concluding section of his paper Mr. Lanchester emphasized the fact that we are very far from having reached finality in shop lighting; and Sir Arthur Liberty, the Chairman, and other prominent architects who joined the discussion agreed with the author as to the "restless effect" of a multiplicity of lighting points and the need for more artistic and judicious methods.

We are glad to have this expression of opinion on the part of the architects, who are in a position to secure that the lighting is considered at a reasonably early stage in the planning of the building. In the case of large departmental stores the lighting is a most valuable means of attracting and holding custom, and there are many possibilities in the way of novel and artistic methods of illumination that have hardly been touched as yet. Not infrequently slight modifications in the architectural design would enable remarkable results to be obtained. What is needed is for the architect to take the expert on illumination into his confidence at an early stage in the design of the building, so that both the illumination and the style of the interior can be worked out together, the lighting thus being—as it should be—an integral part of the whole design.

Royal Institute of Public Health: Paris Congress.

During Whitsun week the Annual Congress of the Royal Institute of Public Health is to take place in Paris. The meeting is under the patronage of the French Government, and will doubtless be an important one. Readers will have observed from the note published in our March number (p. 154) that a special section has been arranged dealing with industrial hygiene. This section will be presided over by Sir Thomas Oliver, and the writer has been asked to open a discussion on 'Lighting as a Health Factor in Occupation, and its Influence on the Prevention of Accidents.'

It will be seen, therefore, that the hygienic aspects of illumination are very much to the fore. It is a gratifying precedent for a special discussion on illumination to be organized at an important meeting such as this, and we hope that in the future it will become a regular feature of congresses on hygiene. Light is surely one of the most potent influences on the health of mankind. It would be difficult to find any cause appealing to a wider circle, and influencing directly a larger section of the public than good illumination.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London. 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

A Draft Standard Specification for Street Lighting.

A MEETING of the Society was held at the house of the Royal Society of Arts at 8 P.M. on Tuesday, April 15th, the chair being taken by Mr. F. W. Goodenough. The minutes of the last meeting having been taken as read, the names of applicants for membership were presented in the usual way, and the chairman then called upon Mr. A. P. Trotter to read an abstract of his paper entitled 'Standard Clauses for Inclusion in a Specification of Street Lighting.' In introducing the lecturer he recalled that the question of a standard specification for street lighting had been under consideration by a joint committee, consisting of the Institutions of Gas, Electrical, Municipal and County Engineers, and the Illuminating Engineering Society. Advantage had now been taken of the impartial platform of the Illuminating Engineering Society in order to provide an opportunity for a general discussion on the subject, and they were most fortunate in receiving a paper from such an authority as Mr. A. P. Trotter.

Mr. Trotter then proceeded to give a summary of the contents of his paper, which had already been printed and circulated. (This paper will be found *in extenso* on pp. 241–257.) He explained some of the conflicting views that the Committee had been endeavouring to reconcile, and pointed out the distinction that had been drawn between the illumination of important streets, and the lighting of less important streets which was more in the nature of "beacon lighting." He also discussed the question whether candle-power or illumination should be measured, and showed how this had been dealt with in a special clause in the draft specification. He hoped that the discussion would be treated in as broad a manner as possible. A specification of this kind, to be of permanent benefit, should be applicable to the whole country; it was therefore very desirable to get as near unanimity as possible, and to recognize that the present tentative specification would naturally be in the nature of a compromise.

The CHAIRMAN then called upon MR. PATCHELL, the Chairman of the Joint Committee, to open the discussion, and to propose a vote of thanks to the author. Mr. Patchell explained the circumstances that had led the Committee to take advantage of the paper by Mr. Trotter to present the specification for open discussion. He made special reference to the work of the surveyors on this committee, pointing out how their classification of streets had coincided exactly with the grouping based on measurements of illumination.

An interesting discussion then followed, in which Mr. J. G. Clark, Mr. John Darch, Mr. K. Edgcumbe, Mr. Haydn T. Harrison, Mr. Franklin T. Thorp, and Mr. Robert Watson took part.

Several communications received from authorities in the United States and on the Continent also appear in this number (see pp. 272–279).

The Chairman then announced that, in order to provide opportunity for as full discussion of the paper as possible, it had been decided to devote a second evening to the discussion, which would be resumed on **Tuesday, April 29th,** at 7.30 P.M. This terminated the proceedings, and most of those present adjourned to the library, where tea and coffee were provided.

New Members of the Society.

THE names of the applicants for membership, read out at the previous meeting on March 11th,* have now been formally announced for the second time, and these gentlemen were declared Members of the Illuminating Engineering Society. In addition, the names of the following gentlemen have been duly submitted and approved by the Council, and were read out by the Hon. Secretary at the meeting of the Society on April 15th :—

Ordinary Members :—

Aldrich, T. H.	Engineer, National X-Ray Reflector Co., 235, West Jackson Building, CHICAGO, U.S.A.
Bohle, H.	Professor of Electrotechnics, South African College, CAPETOWN, S. Africa.
Bond, J.	Engineer and Manager, Gas Works, SOUTHPORT.
Cross, W.	Electrical Contractor, Messrs. Falconer, Cross & Co., 7 and 9, Ridley Place, NEWCASTLE.
Dumont, E. S.	Electrical Engineer, Benjamin Electric Co., Ltd., 31, Peter Street, LONDON, W.
Helps, D. H.	Engineer, The Gas Works, King's Road, READING.
Hollanda, R. de	6, Tavistock Square, LONDON.
Mostyn, R. J. F.	Electrical Engineer, Assoc. of Inst. of Elec. Engineers, Sandown, St. Minver Road, BEDFORD.
Tucker, A. G., A.M.I.E.E.	Electrical Engineer, 71, Grant Street, GLASGOW, W.
Walker, R. E.	Elec. Engineer and Contractor, Widemarsh Street, HEREFORD.

---

* *Illum. Eng.*, Lond., April, 1913, p. 174.

OFFICIAL NOTICE OF ANNUAL GENERAL MEETING.

The ANNUAL GENERAL MEETING will take place at the House of the Royal Society of Arts (18, John Street, Adelphi, London, W.C.), on TUESDAY, JUNE 3rd, at 5.30 p.m., when the Report of the Council for the past Session will be presented.

It is hoped that all members will make a special effort to be present.

Standard Clauses for Inclusion in a Specification of Street Lighting.

By A. P. Trotter.

[This paper was presented at a Meeting of the Society, held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, on Tuesday, April 15th, at 8 p.m., a special invitation being issued to Members of the Illuminating Engineering Society, Institution of Electrical Engineers, Institution of Gas Engineers, and Institution of Municipal and County Engineers to take part in the discussion.]

Contents.

1. Standardization.
2. The Joint Committee.
3. Competition in Street Lighting
4. Illumination.
5. Objections to the Illumination Basis.
6. Horizontal, Vertical, or Direct Ray Measurements.
7. Average, or Maximum and Minimum ?
8. The Minimum.
9. The Report of the Surveyor Members.
10. The Photometric Report.
11. The Classification.
12. The Final Work of the Committee.

Appendixes.

A. Standard Clauses for inclusion in a Specification of Street Lighting.
B. Draft Requirements for a Street Photometer.

Standardization.—One of the features of engineering industry of the present century has been the effort to standardize. It was predicted that it would be difficult to induce competing manufacturers to meet, and that it would be impossible for them to agree. So wrong were these anticipations that, in some cases, standardization has been overdone. In others it has been premature and ill-advised.

It has been said that consulting engineers need more standardizing than any one else ; while these reply that, with a set of standard specifications, a model form of conditions for contracts, and the services of the National Physical Laboratory, there will be nothing left for the consultant but the witness-box.

Standardizing implies compromise or give-and-take between conflicting interests. The essential end to be standardized must be distinguished from the means to that end. To standardize details is likely to hinder progress and to check orginality.

The Joint Committee.—In the discussion on the paper read by Mr. Haydn T. Harrison before the Institution of Electrical Engineers on November 24th, 1910, it was suggested by Mr. C. P. Sparks that " the Institution would do a great public service by appointing a Committee which would draw up a standard specification for street lighting....The specification should be drawn up on broad lines, taking into consideration not only the electrical and gas interests, but also what is wanted in the public interest."

A preliminary memorandum was

prepared in January, 1911, by Mr. Frank Bailey, describing the ordinary rule-of-thumb contracts per lamp and the vague reference to candle-power without mention of angles or position of test, and the advantage of specifying that which has really to be paid for, namely, the actual light given where it is required, or, in other words, illumination. The memorandum went on to indicate the lines on which a tender for street lighting might be drawn, and a first draft of heads of agreement on these lines was provisionally settled at a meeting on January 24th, 1911.

The following is a list of the members of the Joint Committee :—

Representing the Institution of Electrical Engineers.

Mr. W. H. Patchell, Chairman.
Mr. Frank Bailey, Prof. J. T. Morris,
Mr. K. Edgcumbe, Mr. S. L. Pearce,
Mr. S. Z. de Ferranti,
Mr. H. F. Proctor,
Mr. H. T. Harrison, Mr. A. P. Trotter.

Representing the Institution of Gas Engineers.

Mr. W. Doig Gibb (resigned Dec., 1911).
Mr. S. Y. Shoubridge, Mr. R. Watson.

Representing the Institution of Municipal and County Engineers.

Mr. E. J. Elford, Mr. T. W. A. Hayward,
Mr. G. F. Carter, Mr. E. B. B. Newton,
Mr. N. Scorgie.

Representing the Illuminating Engineering Society.

Prof. Silvanus P. Thompson,
Mr. L. Gaster, Mr. J. W. Ife,
Mr. F. W. Goodenough,
Mr. A. H. Seabrook (resigned Nov., 1911).

Independent Member co-opted by the Committee.

Mr. J. W. Bradley.

At an early stage it was settled that, if a draft specification could be agreed upon, it should be presented by the delegates of each Institution to their Council, and that until these had taken action the deliberations of the Committee should be in private.

At a meeting on March 7th the draft was further discussed, and it was provisionally agreed : (1) The specification to be based on illumination, the unit to be the foot-candle. (2) The standard of comparison to be the minimum horizontal illumination at a height of 3 ft. 3 in. above the ground level. (3) The maximum horizontal illumination at a height of 3 ft. 3 in. above the ground level shall not be more than — times the minimum. (4) When the horizontal illumination cannot be conveniently measured, or is below the useful range of the instrument available, it may be calculated from observed data.

At this meeting several members raised objection to basing the specification on illumination instead of candle-power ; and it was agreed that the author should prepare a statement supporting the first clause, and that Mr. H. T. Harrison should prepare a statement of objection to it. This account of the work of the Committee will now be interrupted, and an attempt will be made to present and to amplify the two statements, and to discuss in as impartial a manner as possible the general subject which was debated at some seventeen or eighteen meetings. In doing this mathematical treatment will be suppressed, and details of photometry will be avoided as much as possible.

Competition in Street Lighting.—Until the beginning of the present century, although gradual improvements had been taking place in both electric and gas lighting, the demand for better street illumination was insignificant. As in certain other developments of civilization, this demand was created by the supply. More powerful lamps, owing their existence to research stimulated by competition, were offered by the makers before they were asked for by the purchasers. During the last few years a real necessity for better street lighting has arisen, owing to the increasing speed of motor traffic. Neither the gas nor the electrical engineer is afraid of competition ; on the contrary, they thrive on it ; and the public gain more than anybody, though they know nothing of the

science, of the art, or of the sport of the struggle. In a great contest sporting instinct calls for the laws of battle and the rules of the game. In this spirit delegates from opposing camps, captains from rival schools, met round a table to devise a broad standard specification for street lighting.

Illumination.—Illumination depends on the quantity of light falling on or received by a surface. It has nothing to do with the colour or reflecting power of a surface. A surface facing a source of light of 1 candle-power and at a distance of 1 ft. from it, or 16 candle-power at 4 ft., or 100 candle-power at 10 ft., receives unit illumination, and this is called 1 foot-candle. The surface may be a chessboard with black and white squares, or a looking-glass: it receives unit illumination.

The brightness of an unpolished surface depends on two factors—the illumination, and the proportion of light which the surface can reflect. A dark grey surface reflecting 5 per cent of the light falling on it may have exactly the same appearance as a pale-grey surface reflecting 25 per cent if the former receives five times as much illumination as the latter. The quality called brightness (or surface-brightness, to distinguish it from the intrinsic brightness of a self-luminous or translucent body) is, therefore, a product of the two factors illumination and the coefficient of diffused reflection.

Sir William Preece, in his Reports to the Streets Committee of the City of London, in June and August, 1884, pointed out* that, if the illumination is up to a certain specified standard, it does not concern the public whether it is produced by a few lamps of large candle-power or by more lamps of less candle-power, or whether tall or shorter posts are used, within certain limits. The lamps must, of course, be so arranged that they are free from glare, and must be placed to the satisfaction of the surveyor, so that they do not interfere with the traffic or with the amenities. While the surveyor, therefore, should have a voice also in the maximum and minimum height of the lamps, in practice this will be found, in most cases, to take care of itself. It remains for the contractor to settle the candle-power, the polar distribution, the kind of reflector or lantern, and other details. Where existing lamp-posts are to be used, his task is generally more simple.

Objections to the Illumination Basis.—One of the objections, from a contractor's point of view, to the illumination basis of a specification is that it gives him some trouble in calculating and designing the scheme. A contractor of the old school would like a laboratory test of candle-power on a sample lamp, and he could then turn them out by the hundred. He is now aware that the polar curve of light distribution must be taken into account, or, at all events, the candle-power at certain specified angles. Such a contractor holds that the means should be separated from the end. It is his business to sell the lamps, and in some cases to provide the electric supply or the gas, but he considers that, so long as the lamps give the specified candle-power, his responsibilities should end there, and the purchaser must arrange the lighting to suit the needs of the case. "Tell me," he says, "how many lamps you want, and of what candle-power, and I will supply them; but don't bother me with mathematical tables, nor worry me with cosines, and, for Heaven's sake, don't drag in 4π." This school of contractor is not to be disparaged. He knows his business, he has done what he has been asked to do: we are building on the foundations that he has laid.

On the other side is the municipal or county engineer or surveyor. Experienced men of this profession have studied the needs of their district, know what the contractors can provide, and understand how to use it when they

* "The photometers in common use enable one to measure the intensity of a source of light only, that is, they tell us that a gas lamp is equal to 10 or 15 candles, or an electric arc lamp is equal to 100 or 1,500 candles, but they do not tell us the illumination of the centre of the roadway of a street, or the side of a house, or the window of a shop, when lighted by many lamps of different kinds and in various positions. I wanted to determine how a street was lighted by measuring the illumination of its surface at any spot, quite irrespective of the way in which that illumination was produced."—Preliminary Report, June 4th, 1884, p. 23.

have got it. It is to them that we should naturally turn for advice about a specification for street lighting. But we find that while each man knows his own job, he sometimes has a difficulty in appreciating the needs of a totally different district, and cannot generalize, or even explain, the principles on which he successfully designs his street lighting. He may classify lamps as giving 3,000, 1,800, 300, 180, and 90 candle-power, and arrange them to suit the streets of the district in which he has spent most of his life, but this is not a very useful guide for other engineers. In many cases he works better by instinct than by trying to make rules which are merely for himself to follow.

Now that illuminating engineering, the subject of many books and of courses of lectures at technical colleges, is becoming recognized as a branch of the great profession, the question arises: How much of this is the province of the borough engineer, and how much of the contractor? While there are notable instances of municipal engineers who are well able to look after their street lighting, to settle the position of each lamp, its height, the character of the reflector, the angles at which they think the candle-power should be measured, it cannot be expected that the majority are anxious to go into the details of this subject, nor would they be willing to lay these before their street-lighting committees. It seems better that the lighting authorities should settle what it is they want to buy, and, having specified it, to leave details to the competitive skill and wider experience of contractors. What, then, are these authorities "out to buy"? Not lamps, not candle-power, but illumination.

The needs of different cases of street lighting differ amongst themselves more widely than do other services. Water supply and sewage disposal are full of technicalities which are left to experts, but the main object is to get abundance of the purest water and a sewerage system so complete that few persons are aware that it exists. So long as there is as high illumination in the main streets as the town can afford, and as much in the side streets as the ratepayers desire, candle-power *per se* does not concern them, and need not greatly trouble their engineers or surveyors. A specification based on illumination will allow the better grades of street lighting in different towns to be accurately compared.

Another objection to the illumination basis arises from the impression that it is easier to measure candle-power than illumination. It is desirable that details of photometers should be excluded from this paper and from the discussion which it is hoped to raise; but since the question of measurement constitutes an objection to the illumination basis, this matter cannot be disregarded. The draft specification which will be found in Appendix A recognizes several classes of illumination, the lowest having a minimum of 0·01 foot-candle on a horizontal plane 3 ft. 3 in. above the ground. While these classes are of importance so far as quality is concerned, they cover only about 20 per cent of the street lighting of this country. It is proposed that the balance of 80 per cent shall be measured by candle-power. The most enthusiastic supporters of the illumination basis agree that there are instrumental difficulties in measuring very low illuminations. Photometers exist which give a good measurement at 0·002 foot-candle, but the light reflected from the clouds on a dark night or from mist or smoke is difficult to separate from low illumination due to feeble and distant artificial light. In order that the number of qualified photometers may not be reduced, the limit of 0·01 has been fixed; but where correction has to be made for stray light or for steady moonlight, the photometer should be able to give a good measurement at 0·005 foot-candle. This applies equally to candle-power photometers, and is equivalent to a 16 candle lamp at 63 ft.

There is also an instrumental difficulty in measuring illumination which falls on a horizontal screen at a large angle of incidence. The draft specification does not provide that the screen shall be horizontal. If desired, it can be inclined to face any lamp, or,

in other words, to receive the direct ray at zero angle of incidence.

In the case of that class of street lighting which constitutes by far the largest proportion, and particularly in the extreme case such as the lighting of a country road, the lamps serve mainly as beacons. The illumination on the ground or on any other surface is only useful in the immediate neighbourhood of each lamp. Candle-power is obviously, then, the basis. It is an advantage that the light shall be thrown to a distance, and it is therefore proposed that the candle-power shall be measured in the direction of the thoroughfare, at an angle of ten degrees below the horizontal. The direction of the road is mentioned in order that advantage may be taken of any reflector which helps the lighting in this respect. This means that the ray strikes the ground at a distance from the post measured along the street 5·67 times the height of the lamp. As it is convenient to make the measurement at 3 ft. or 4 ft. from the ground, this must be subtracted from the height of the lamp. With a 20 candle-power lamp 12 ft. high, a photometer 4 ft. high will receive the 10-degree ray if it is placed 45 ft. 4½ in. from the post. The illumination on a photometer screen facing the lamp will be 0·0094 foot-candle. A smaller angle below the horizontal would mean greater distance or a higher photometer; a larger angle would mean a less important ray. Until the class of street lighting is reached which would be produced by a row of 12½ candle-power lamps on posts 10 ft. high and 50 ft. apart, or 50 candle-power lamps on posts 17 ft. high and 100 ft. apart, or any of the 200 cases given in the table attached to the Specification, it is proposed that this simple measurement of candle-power shall suffice.

But for the more brilliant, though less frequent classes of lighting, where there is no difficulty in measuring the illumination produced, there are several reasons for adopting this as a basis instead of candle-power. The first one has already been mentioned. The public want light, not lamps. Another reason is that this allows the fullest scope for invention, economical spacing, and minimum cost. A third is that if more than three or four lamps contribute the lighting of any part of a street, the *resulting effect* cannot be obtained by measuring the candle-power of each lamp from that position. The addition of these candle-powers gives no indication of the lighting of the spot in question, unless it is reduced by calculation to the resulting illumination. Nor does the measurement of the illumination on a screen facing each lamp in turn help matters, since it never faces them all at the same time. But if a horizontal screen is set up at this spot it receives illumination from each lamp, and the illuminations are automatically added together, and may be measured simultaneously. Sir W. Preece's idea was to measure the illumination on the ground, and all his early work on street lighting was so done, and a good deal might be said for it. But some people think that the plane should be at 3 ft. or 4 ft. from the ground, approximating to the mean height of objects. Such a height allows a larger choice of photometers, for in some cases the observer is obliged to look through an eye-piece. It is a mistake to set the instrument up too high, for it begins to approach the lamps too closely. This has the effect of increasing the measured illumination in the neighbourhood of the lamp, but at a distance from a lamp-post greater than one and a half times its height the difference is not appreciable.

There is one well-known practical candle-power photometer for street work made in England; there may be two. There are also French and German instruments. There are at least five useful illumination photometers on the English market, besides well-known American and Continental kinds. All of these are suitable also for measuring candle-power by direct ray, and most are adapted for measuring illumination received on a horizontal plane. They are much more portable and less expensive than candle-power photometers; they do not fatigue the eye; they are all graduated by experiment, and do not attempt to rely on a theoretical law.

Horizontal, Vertical, or Direct Ray Measurements.—The aspect of the plane on which the illumination should be received has been discussed by several writers. Some claim that it should face the lamp as in candle-power measurement, others that the plane should be vertical. There is something to be said for each of these. The difference between the illumination in the two cases is insignificant at a distance from the lamp-post greater than twice its height. The illumination on the vertical plane falls off in the neighbourhood of the lamp, and vanishes when it is brought immediately below it. Bill stickers, or rather their clients, would approve of vertical plane illumination.

The two advantages of the horizontal plane are that: (1) if the illumination on it is sufficient, that on the other planes must be better; and (2) the illuminations received from all neighbouring lights add themselves together and give one single quantity which may be measured by one single observation. The economy of time and saving of calculation is enormous.

The photometric survey of a street may be carried out in much less time and with equal accuracy by making a few measurements of illumination on a horizontal plane than by making candle-power measurements. In the former case no calculations whatever are needed; all illumination photometers are direct-reading. Candle-power measurements entail calculations for each observation, and further calculations involving the use of tables of cosines are needed to reduce candle-power measurements to illumination. It is probably the tediousness of this mathematical work and the distrust of novel instruments that produce a reluctance to accept illumination as a basis for street lighting. When the lighting of a street is judged, as the specification recommends, by the minimum illumination, the labour is again largely reduced. It is found in practice that it is very easy to find the minimum illumination, and this extends over a considerable area. Even when six lamps contribute to the result, only a little care is needed to prevent one of them from being blocked by the observer's body.

Another objection to the horizontal plane measurement is that it takes account of reflected light from buildings. A contractor may feel that this is a matter beyond his control, and he should not suffer if the houses in a street become dirty or are painted a dark colour. It is true that a street with light-coloured houses seems to be better lighted than when the buildings are dingy, and it may be argued that, if it seems to be better lighted, it *is* better lighted whatever the photometer may say. True, the judgment of the common-sense man in the street is of far greater value than that of any photometer; but experiment shows that in ordinary West-End London streets, with painted stucco, the difference, as measured on the photometer, is extremely small, and is generally beyond the practical limits of error.

Reflected light from the sky is of greater importance. This must be reckoned with in accurate candle-power photometry by narrowing the field of view, and it is one of the reasons why illumination photometry must give place to candle-power measurements when the light is feeble. On the other hand, it is difficult to know how to deal with the field of view in the candle-power photometry of powerful lights if there is a trace of mist or dust. The direct light being obstructed, as much diffused light as possible should be included, so long as it all belongs to the light to be measured, and is all true, diffused light from the mist, and not reflected from buildings.

For these and other reasons a considerable majority of those who have given attention to this matter agree that the illumination received on a horizontal plane is the best measure of the lighting of a street. Whether this is directly observed with a suitable instrument, or whether it is calculated from several observations of illumination or of candle-power, is of minor importance. It is probable that some of those who disagree with the proposal to measure the illumination directly on a horizontal plane

have never used, or perhaps seen, a photometer for that work.

A photometer for use in a test-room may be graduated directly in candle-power, but an instrument to be used in the streets at various distances from the source of light must be graduated in foot-candles. The reading, multiplied by the square of the distance in feet, gives the candle-power.

Take a case from the table in Appendix A: A lamp 12 ft. high, the photometer set up 3 ft. 3 in. from the ground, and 50 ft. from the lamp-post (Fig. 1). As we do not want to know the actual distance of the lamp from the photometer, but the square of that distance, we take $(12-3{\cdot}25)^2+50^2=2577$. Let the illumination measured on the photometer screen directly facing the light be 0·029 foot-candle. Then the candle-power of the lamp is $0{\cdot}029\times2577=75$.

The illumination which would be received on a horizontal screen is less than 0·029 in the same proportion that the height of the lamp is less than the slant distance from the lamp to the screen. The slant distance, the square root of 2577, is 50·77. The ratio 8·75 : 50·77 is 0·1725, and this, multiplied by 0·029, is 0·005, the illumination required. Or the angle of incidence may be calculated or measured. It is easier to measure it to 1 degree than to level the photometer to that accuracy. To calculate it, find the tangent. This is the ratio of the horizontal distance to the height; $50/8{\cdot}75=5{\cdot}71$. The angle is about 80 degrees, and the tables give the cosine 0·1725, the ratio required. Another lamp 50 ft. away doubles the illumination, making 0·01, for which the table is calculated.

This is a case in which the illumination on the horizontal plane would be difficult to measure with some photometers if there were only one lamp, on account of the feeble illumination 0·005 and the large angle of incidence; an error of 1 degree makes 10 per cent difference at this angle. But when the illumination received at the midway point from the two lamps is measured, the reading 0·01 should give no difficulty, and a slight inclination of the photometer towards one lamp is balanced by its inclination away from the other. Some calculation is needed to find the candle-power, more is required to deduce the illumination from it, but none whatever is necessary if the illumination is measured directly on a horizontal screen.

Average, or Maximum and Minimum?—Assuming, then, that for the higher classes of street lighting the illumination received on a horizontal plane 3 ft. 3 in. above the ground is to be the basis of the estimation of the lighting, we have to consider how this has to be treated.

In all these classes some attempt is made towards uniform distribution. The mean value suggests itself as the one to be considered, but if this is

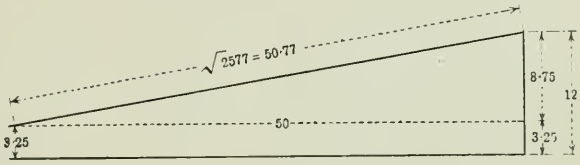


Fig. 1.

investigated it will be found to involve a considerable amount of calculation. It is easy to go wrong in this. In the theoretical consideration of a case, the mean value may be found by dividing the surface into a number of squares and calculating the illumination at the middle of each. Or contour or iso-lux curves may be drawn from numerous photometric measurements or from calculation, and the areas measured by planimeter. Or the simple definition of illumination in terms of a light of unit candle-power at unit distance may be replaced by the more complex idea of flux-density. A source of light giving 1 candle-power in every direction is said to give 4π lumens, and the foot-candle is defined as 1 lumen per square foot. Integrating the polar curve of light distribution between the limits of the useful rays, the mean flux-density may be obtained by dividing the total lumens by the area of the street surface. The result is given in simple foot-candles. He who does this

thing comes out at the same door wherein he went, and is likely to achieve that which he intends if he does not lose his way while he is inside. Most of us prefer to remain outside.

While the theoretical consideration of the mean illumination is intricate, the photometric observations necessary to yield a fair average would be very numerous, and would, in fact, amount to a photometric survey of the street. Fortunately, a little consideration shows that, while the mean illumination of a street may be up to a reasonable standard, it may have alternations of dazzling brilliance and dismal darkness. This proposal may, therefore, be discarded.

Some have suggested that the average between the best and the worst parts should be taken; but the area of the former always exceeds that of the latter, and the ratios extend in practice over such wide limits that this comparison will not serve.

The Minimum.—The most satisfactory test appears to be the simple minimum illumination. Any excess of light may be regarded as a voluntary benefaction from the lighting authority or an unavoidable concession by the contractor. Neither party is likely to be too generous in this matter, but the draft Specification provides that the height at which it is proposed to place the centre of light of each type of unit above the street surface is to be given in the schedule to the tender. This gives the lighting authority an opportunity to control excessive light.

The Report of the Surveyor Members.—The preliminary memorandum, to which reference has been made, stated that an illumination basis would necessitate the grading of thoroughfares into, say: special; first class, for main thoroughfares; second class, for minor thoroughfares; and third class, for country districts or pilot lighting.

At an early stage of the work of the Joint Committee it was recognized that some such classification was essential, and that they must have some practical data to work upon, and copies of street lighting tests were supplied by Mr. A. A. Voysey, Mr. F. Bailey, Mr. F. W. Goodenough, Mr. Haydn T. Harrison, and Prof. J. T. Morris. (See reference letters F_1 to N_1 on Fig. 3, to be described later.)

After these tests had been considered by the Committee, the question of classifying them was discussed, and the Surveyor Members were asked to visit some streets for the purpose of judging what kind of classification would be possible. The four delegates of the Institution of Municipal and County Engineers, Mr. G. F. Carter of Croydon, Mr. T. W. A. Hayward of Battersea, Mr. E. B. B. Newton of Paddington, and Mr. N. Scorgie of Hackney, met on the evening of May 22nd, 1911, and in a car kindly placed at their disposal by Mr. F. W. Goodenough visited numerous streets in the City of London, City of Westminster, and the Boroughs of St. Pancras, Marylebone, Paddington, Kensington, Holborn, Finsbury, Islington, Hackney, and Shoreditch.

Their Report is of value in itself, owing to the practical experience of these delegates and to the wide area examined by them, but additional interest is added by a confirmation of their estimates, which will be referred to later.

In the first place they excluded the lighting of such streets as Whitehall, Regent Street, Cheapside, Cannon Street, Oxford Street, and others, because they are thoroughfares of a special character, and the lighting is more than is usually necessary for ordinary traffic. They thought that for any public lighting purposes streets might well be grouped under three headings: (*a*) First-rate main lines of thoroughfare; (*b*) auxiliary roads and relief main roads; (*c*) side and unimportant streets.

Under (*a*), it was thought, might be grouped such roads as Rochester Row, S.W., Ashley Gardens, S.W., St. James's Square, S.W. (in examining St. James's Square the different effects at the corner of York Street, where on one side was a clean white house and on the other a dark-coloured one, was considered by the Surveyors to be very noticeable), Mount Street, East of South Audley Street, Park Lane,

Portman Square, Baker Street, St. Marylebone Road, Park Road, St. John's Wood Road, Maida Vale near Elgin Avenue, and Bayswater Road near Victoria Gate.

Under (*b*), it was thought, might be grouped such roads as Vincent Square, S.W., Manchester Street, Harley Street (this was regarded as a rather superior amount of lighting for a class (*b*) street), and Cambridge Street.

Under (*c*) they included such roads as Buckingham Road, Hackney; Culford Road, Hackney; Sandringham Road, Hackney; and main roads across the Park from Victoria to Albert Gates. More names of streets could have been given, but the Surveyors were of opinion that those selected, which include examples of both gas and electric lighting, were reasonably indicative of the standards.

The Photometric Report.—It appeared desirable that this purely qualitative classification should be checked by quantitative measurements, and Mr. K. Edgcumbe, Prof. J. T. Morris, and the Author undertook to make a series of tests on the basis suggested by the draft Specification, namely, the minimum illumination on a horizontal plane 3 ft. 3 in. from the ground, as well as the maximum illuminations. In order to secure a long working evening the test was postponed, and was made on October 26th, 1911.

About eighty-eight photometric measurements were made, besides measurements of distance and angle, at thirty-one places. There was no moon, and little, if any, reflection from wet streets. From two to six readings were taken at each place; the mean of each set is given. The readings agreed fairly well together—*e.g.*, Baker Street, 0·043, 0·046, J.T.M.: 0·045, K.E.: 0·046, A.P.T. Higher accuracy was not sought for, since the variations between the readings were much less than those found between the neighbouring lamps or between successive measurements of the same lamp, due to flickering in the wind. A Trotter photometer was used. No difficulty was found in comparing lamps of different colours.

Owing to the time occupied in getting over the ground (between 9 and 10 miles), setting up the instrument, making and recording the photometric and other measurements, and starting off again, it was not possible to visit all the streets mentioned in the Report of the Surveyor Members.

The work began in St. James's Square at about 7 P.M. The minimum places were easily found, and a second photometer (carried in the hand) showed that for a distance of 6 ft. or 8 ft. in any direction from the spot chosen there was no appreciable difference in the illumination. Five or six lamps contributed to the illumination, and there was little difficulty in finding a position in which the observer's body did not cast a shadow on the photometer. Comparative measurements were not made opposite the Sports Club (No. 8) and the Portland Club (No. 9), for, while the Surveyor Members pointed out that the former was a clean white house and the latter

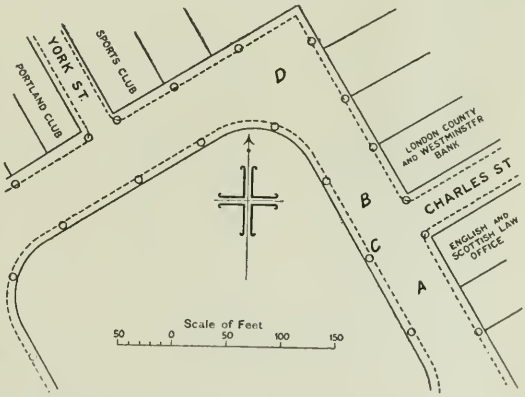


FIG. 2.—Part of St. James' Square.

a dark-coloured one, the street lamps are closer together in front of the former, and a good deal of light was emitted by the lamp over the door and from the windows. Fig. 2 shows the positions of the first four sets of measurements, A, B, C, and D.

The lighting of South Audley Street was so similar to that of Mount Street that only one set of measurements was taken. It may be observed that the

highest maximum was found in Bayswater Road near Victoria Gate (2·28 foot-candles), and this was sixty-seven times the minimum, giving a larger ratio than in any other street measured on that evening. But the street, having the Park on one side and gardens on the other, receiving no reflected light from houses, was lighted well and sufficiently for its important traffic, the minimum 0·034 being a good one. The ratio of maximum to minimum in Harley Street was 18, being less than in any other of the streets measured. Park Lane ranks next in this respect with a ratio of 19.

Star Street afforded an example, and exploration was pushed as far as Lancaster Road, Notting Hill, and Latimer Road in the slums of Notting Dale, before badly lighted streets could be found. The darkest spots were chosen in the last three streets, but care was taken in all cases that no shadow from a lantern frame fell on the photometer. Accurate levelling was necessary in these later measurements.

The results of these photometric tests—which are set out in full in Table I. and (together with others already referred to) in Fig. 3—are rather remarkable when they are com-

Minimum Illumination in foot-candles received on a horizontal plane 3 ft. 3 in. from the ground.

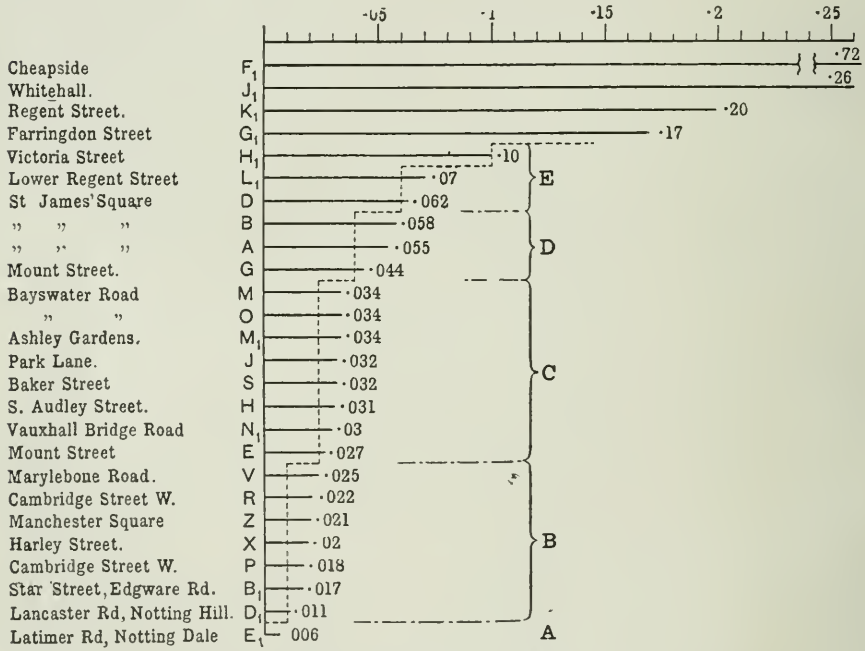


FIG. 3.—Results of photometric measurements.

By inadvertence, the class letters are not the same as those suggested in the Specification. A represents the lowest class, viz., minimum below 0·01 foot-candle. B is from 0·01 to 0·025. C is from 0·025 to 0·04. D is from 0·04 to 0·06. E is from 0·06 to 0·1.

The Surveyor Members regarded Harley Street as having a rather superior amount of lighting for a (*b*) class street; but the lighting of the Borough of St. Marylebone is so uniform that no lower illumination could be found in that district. Hackney being rather too far, streets of the (*c*) class were looked for in Paddington, pared with the Report of the Surveyor Members. It shows that they so accurately classified the streets by eye that, when the measurements of minima are arranged in order, they fall exactly in the classes. The class (*a*) has an illumination on a horizontal plane 3 ft. 3 in. from the ground, not less than 0·025 foot-candle. The minimum illumination in

TABLE 1.

Measurements of Maximum and Minimum Street Illumination made by K. Edgcumbe, Prof. J. T. Morris, and A. P. Trotter, 26th October, 1911.

	Class in Surveyors' Report.	Street.	Description or nearest house.	Illumination on a horizontal plane 3 ft. 3 in. from the ground. Foot-candles. Minimum.	Maximum.	Max./min.	Distance of maximum from lamppost.	Angle of incidence.	
A	a	St. James Square	Middle of road opposite English and Scottish Law Life Office	·055					A
B		"	Middle of road opposite London County and Westminster Bank	·058		32			B
C		"	Lamp opposite Charles Street		1·86		5 ft. N.E. of lamp		C
D		(7.25 P.M.)	Middle of road, N.E. corner of square	·062					D
E	a	Mount Street	No. 97	·027					E
F		"	No. 15		0·86	24	13 ft.		F
G		"	No. 103	·044					G
H	a	S. Audley Street	No. 33	·031					H
J	a	Park Lane	Opposite garden of Grosvenor House, W.	·032					J
K		(8 P.M.)	" E.		0·60	19	19 ft. 6 in S.	46°	K
L	a	Bayswater Road	1st lamp E. of Victoria Gate, S. side of road ...		2·28		5 ft.	33°	L
M		(9.45 P.M.)	" " N. " ...	·034		67			M
N		"	2nd " " N. " ...		1·79		5 ft. 10 in.	30°	N
O		"	" " " S. " ...	·034		53			O
P	b	Cambridge Street	No. 43 N. " ...	·018					P
Q		"	No. 47 N. " ...		0·63	31	5 ft.	32½°	Q
R		"	No. 13 N. " ...	·022					R
S	a	Baker Street	No. 13 E. " ...	·032					S
T		"	No. 73 W. " ...		1·24	18	4 ft. 5 in.	30°	T
U		"	No. 11 E. " ...		0·68		5 ft. 6 in.	32°	U
V	a	Marylebone Road	Middle of Madame Tussaud's, N.	·025					V
W		"	" "		0·60	24	6 ft. 6 in.	35°	W
X	b	Harley Street	No. 130 E.	·020					X
Y		"	No. 126		0·37	18	5 ft. 5 in.	31°	Y
Z		Manchester Sq.	No. 13 S.W. corner	·021					Z
A_1		Lr. Berkley St.	Corner of Manchester Square		0·54	26	6 ft. 8 in.	36½°	A_1
B_1		Star St., Edgware Road	No. 78 S.	·017					B_1
C_1		(11.40 P.M.)	St. Michael's School N.		0·83	49	4 ft. 3 in.	26°	C_1
D_1		Lancaster Road, Notting Hill	No. 19	·011					D_1
E_1		"	Nos. 14-15		0·53	48	4 ft. 3 in.	24°	E_1
F_1		Latimer Road, Notting Dale	No. 31 W.	·006					F_1

class (*b*) varies from 0·025 to 0·015, and in class (*c*) it falls below 0·015.

This agreement is noteworthy. It shows that the judgment by eye by experienced men is in accordance with careful photometric tests; that photometric tests of illumination are not mere scientific experiments, but confirm quantitatively in definite figures the judgment of the eye; and, lastly, that the Surveyor Members seemed to have been unconsciously influenced by the minimum illumination in each case, for the maximum illuminations show no sort of agreement. Another result of these tests is to show that the ratio of maximum to minimum illumination is not a matter of importance, and it was agreed by the Committee that this point, which had appeared in the first preliminary draft, should be dropped. If the measurements had been made at the centre of the road they would have been slightly higher, because the minimum places were not always in the middle of the street.

The Classification.—On discussing the proposed classification there appeared, at first, to be a difficulty in dealing with those cases of brilliant street lighting which were not included in the Report by the Surveyor Members. It is clearly a mistake to call it better than first class, for it is necessitated by dense and fast traffic in important thoroughfares. It was decided to invert the order, and to begin with the most extensive, and therefore very important class, in which the minimum is below 0·01 foot-candle, which will be measured by taking the candle-power of the lamps. This class was not designated. The other classes are as follows:—

A.	Minimum at least		0·01	foot-candle
B.	,,	,,	0·025	,,
C.	,,	,,	0·04	,,
D.	,,	,,	0·06	,,
E.	,,	,,	0·1	,,

This leaves some twenty letters available for such higher classes of illumination as the progress of civilization may call for, classes which electric light and gas engineers will be happy to provide when invited.

The Table in the Appen. (p. 16) was originally calculated by Mr. Haydn T. Harrison to show the candle-power required to produce a minimum illumination of 0·01 foot-candle on a horizontal plane 3 ft. from the ground, midway between two lamps of a given height and distance apart.* The column D gives the distance apart, the columns I the candle-power, and the columns θ the angle which the ray makes with the horizontal. The lamps are supposed to give equal candle-power in all directions. The top right- and the bottom left-hand corners of the table represent extreme and unpractical conditions. The figures between the stepped lines represent cases of ordinary practice, but they are not intended to suggest limits. The table shows the economy of placing the lamps as high as possible, subject to practical considerations. Tall lamps in a narrow street waste much light on the walls of the houses.

The Final Work of the Committee.—When the Committee had reached this stage they were asked to consider a draft specification which, while incorporating some of the principles on which the majority seemed to be agreed, directed that the Surveyor should fix the position and height of all lamps, and adjudicate on refracting lenses and reflectors. It was suggested that candle-power should be measured at two angles—20 degrees and 50 degrees with the horizontal. This was fully discussed at several meetings, and attempts were made to reconcile or to

* The Table has been recalculated by Mr. M. Wilson of the Board of Trade. In re-calculating, the height, 3·28 was used instead of 3·25, thus approximating more closely to the metre. The difference in the result, less than half of one per cent, is of course inappreciable. The following is an example:—

H = height of lamp, h = height of photometer, D = distance apart of the lamps, all in feet. Let H = 12, h = 3·28, D = 100. Then $(H-h) + (D/2)^2 = 257604$. Since D/2 is 50, look out in a table of squares and cubes the square of a number rather larger than 5,000, the nearest square to 25760400, and take its cube. This number is 5075, the square is 25755625, and the cube is 130709796875, of which the first five figures are sufficient. But the fourth figure of the square is not an exact fit, and by proportion the cube is taken as 130740. As two lamps contribute to produce 0·01 foot-candle, the cube is divided by $2(H-h) \times 100$. Then 130740 / 1744 = 74·97, which is given in the Table as 75. If the photometer is 3·25 ft. high the candle-power is 74·72. The Table is given as a graph in Fig. 4.

amalgamate the two somewhat different drafts.

Some consideration was given to the relation between density and speed of traffic and the illumination needed. In reply to an invitation from the Committee, Sir Herbert Jekyll, then Superintendent of the London Traffic Branch of the Board of Trade, wrote pointing out the advantage of suspending street lamps from span wires to avoid obstruction by lamp-posts. The Commissioner of Police authorized Superintendent Bassom of the Public Carriage Department to attend a meeting of the Committee, and he gave his opinions on the relation between traffic requirements and illumination. This subject is of considerable importance, but it is somewhat outside the scope of this paper.

A good deal of consideration was given also to Conditions of Contract, and to a Form of Tender, and a specification for details of the suspension of lamps over streets was discussed. It was felt that, while these matters are of great importance, and that the suggestions coming from experienced engineers would be of high value, they were rather beyond the scope of the Joint Committee at the present stage. Some disappointment was felt about this limitation of the draft Specification, but it was finally agreed that circumstances differ so widely in different cities and towns, both as regards the procedure and constitution of lighting authorities and the requirements of the streets, that it would be better to put forward a draft of "Standard Clauses for Inclusion in a Specification of Street Lighting."

These clauses form Appendix A to this paper. They were submitted by the delegates of the four Institutions to their Councils. They were accepted by the Council of the Institution of Electrical Engineers, who authorized the embodiment of the Specification and Appendices, and of the material collected by the Committee in the present paper.

The Council of the Institution of Municipal and County Engineers suggested some useful drafting amendments which have been incorporated in the clauses as printed. The Council of the Illuminating Engineering Society accepted the clauses as a draft and tentative Specification, and recommended that a supplementary specification should be added defining the conditions to be complied with by an instrument for testing illumination or candle-power in the street. This specification has been prepared by the Illuminating Engineering Society, and forms Appendix B. It is hoped that the discussion on the present paper will not be extended to Appendix B, which offers much material for a separate debate.

The Institution of Gas Engineers, while fully appreciating the valuable work which had been done, regretted that they could not agree with the fundamental basis of the suggested Specification, namely, the stipulation of illumination with a stated foot-candle minimum measured on the horizontal plane.

The Joint Committee, in these circumstances, were reluctant to take any further steps until an attempt had been made to review the problem and to give an opportunity for a full debate upon it.

Meantime the author had been invited to contribute a paper before the Illuminating Engineering Society dealing with some aspects of street lighting. It occurred to the Council that the platform of the Illuminating Engineering Society might be utilized for an open discussion on the tentative Specification prepared at a joint meeting of the four bodies interested. This proposal met with the unanimous approval of the Joint Committee. The delegates of the Committee accordingly recommended to the Councils of their respective Institutions that they should fall in with this suggestion and sanction the use in this paper of the material brought before the Committee.

The present paper is the result. The author has endeavoured to state in precise terms the chief objections to the basis of the proposed clauses, and to defend them in a manner which he hopes will conduce to the development of Illuminating Engineering.

APPENDIX A.

Draft Standard Clauses for Inclusion in a Specification for Street Lighting.

As submitted for the approval of the Councils of the Institution of Electrical Engineers, the Institution of Gas Engineers, the Institution of Municipal and County Engineers, and the Illuminating Engineering Society.

Intent of Tender.

1. The Form of Tender headed "Lighting of" includes the provision, fixing, connexion and maintenance of all lamps necessary for obtaining the illumination specified as Class....in and according to the conditions of the standard specification.

Unit of Measurement.

2. This specification is based on illumination the unit of measurement being one foot-candle.

Classification of Streets.

3. For convenient reference the streets are classified as having a minimum illumination as follows :—

Class A	0·01 foot-candle.
,, B.	0·025 ,,
,, C	0·04 ,,
,, D.	0·06 ,,
,, E.	0·10 ,,

Street lighting at a lower minimum illumination than 0·01 candle-power may be specified by the height and distance apart of the lighting units, and the candle-power as measured in the direction of the thoroughfare at an angle of ten degrees below the horizontal.

Minimum Illumination.

4. The "minimum illumination" of a street means the minimum illumination on a horizontal plane at a height of 3 ft. 3 in. above the ground level, and may be measured by means of :—

(*a*) Any suitable illumination photometer, or

(*b*) Any suitable photometer adapted for use in the street which will measure the candle-power of the lamps in those directions which meet at the point of minimum illuminations. In this case the minimum illumination will be calculated by adding together the values of the illumination received from each lamp that materially contributes to the result. In this connexion a useful table will be found in Appendix A (p. 16.)

Special Illumination.

5. The special illumination of certain points indicated on the map such as the corners of cross streets may be dealt with by specifying the positions and height of lamps and illumination at those points.

Type of Photometer.

6. The photometer shall be of the .....type, or of such other type as may be agreed between the parties.

Position of Lighting Units.

7. The approximate positions of the lighting units are indicated on the accompanying map, and are correct within the limits of deviation marked thereon. The contractor shall indicate the positions of all the lighting units, either by completing the said map or by a descriptive schedule accompanying his tender.

Particulars of Lighting Units.

8. Detailed particulars of each type of lighting unit included in the tender must be inserted in the space provided for that purpose in the specification, and must include a statement of the height at which it is proposed to place the centre of light of each type of unit above the street surface, subject to a declared minimum.

Drawings.

9. Drawings of all details as required by the specification shall accompany the tender.

Samples.

10. Samples shall be submitted if required before the acceptance of the tender.

Number of Lighting Units.

11. The number of each type of lighting unit required must be inserted in the tender, with, if called for, a quotation for the provision, fixing, and connexion of the necessary apparatus, and the price per annum for maintenance and for.... hours' lighting, on which the tender is based.

Additional Lighting Units.

12. The contract will provide for additional lighting units if required, such increase not to exceed....per cent, and to be paid for at the quoted rate per lighting unit.

Tests.

13. A test of the illumination shall be made under such normal atmospheric conditions as will not appreciably affect the accuracy of the result, and at a fairly selected point not being in the shadow of a mantle, lamp, electrode, lantern bar, post, tree, or other obstruction.

When a minimum illumination or candle-power of lighting unit is specified it shall be held that such minimum is obtained if the average of the measurements of any three minima between consecutive lighting units of the same type does not fall below it.

Contract to be signed.

14. The tender contains the usual clause that the provisions, conditions, and prices named therein shall form the basis of a contract containing the necessary legal provisions to ensure its fulfilment.

Heads of Clauses for Contract.

15. The contract will also include provisions for :—

(1) Ensuring the lighting of all lamps during fog at prices to be quoted.

(2) Execution of work in such manner as may be necessary for the convenience and safety of the public.

(3) Indemnifying the Council against claims arising out of the execution or maintenance of the work or failure of the lighting.

(4) Payment of moneys due for work done.

(5) Defining the responsibilities of the contractor, and to enforce the conditions of the specification and tender with due regard to practical difficulties.

The following clause being suggested as a guide :—

The intention of the contract is that during the maintenance guarantee period of a construction contract, and during the term of a lighting contract the contractor shall assure himself that the lamps he provides are during lighting hours fulfilling in all respects the requirements of the contract, and he shall not claim relief from the conditions of the contract on the grounds of non-notification on the part of the Council of any failure to comply with the terms of the contract.

NOTE : *Special Clauses.*

1. Each specification may contain special clauses to meet the needs of the particular locality.

Detail Prices.

2. In cases where the specification only calls for the supply, delivery, erection, and connecting up of the lamps, or any of these items, the following further details may be called for :—

(*a*) The cost of the necessary fittings (excluding cost of renewable parts, such as lamps or mantles) delivered on site.

(*b*) The cost of erecting same.

(*c*) The cost of connecting the same to source of supply.

(*d*) The quantity of gas, oil, or electricity, required to maintain the degree of illumination specified, and the pressure at which such gas, oil, or electricity is to be supplied.

Detail Maintenance.

3. It may also be necessary in some cases to call for the cost of maintenance divided up under the following headings :

(1) Maintenance of all parts such as posts, fixtures, or fittings, including cost of cleaning and painting at stated intervals.

(2) Maintenance of all renewable parts such as mantles, lamps, or carbons, including labour connected therewith.

APPENDIX B.

DRAFT REQUIREMENTS FOR THE TESTING AND FOR THE USE OF A STREET PHOTOMETER.

A. *General Requirements for All Classes.*

B. *Requirements for a Candle-Power Photometer.*

C. *Requirements for an Illumination Photometer.*

A. *General Requirements for All Classes :*

(1) *Division or Graduation.*—The instrument to be so made that it can be verified at any time for accuracy of graduation by direct test on a photometric bench with the light falling perpendicularly on the test-plate. This verification to be made at not less than 5 points on the scale, the error under laboratory conditions not to exceed + or − 3 per cent at readings above 0·05 foot-candles.

TABLE PREPARED BY MR. HAYDN T. HARRISON, GIVING THE CANDLE-POWER I NECESSARY TO PRODUCE A MINIMUM ILLUMINATION OF 0·01 FOOT-CANDLE ON A HORIZONTAL PLANE 3 FT. $3\frac{3}{8}$ IN. ABOVE THE GROUND. D IS THE DISTANCE APART OF THE LAMPS. θ IS THE ANGLE WHICH THE RAY MAKES WITH THE HORIZONTAL.

	10 ft.		12 ft.		14 ft.		17 ft.		20 ft.		24 ft.		30 ft.		36 ft.		
D	θ	I	θ	I	θ	I	θ	I	θ	I	θ	I	θ	I	θ	I	D
50	15	12·9	19	10·6	24	9·4	29	8·5	34	8·1	40	8·3	47	9·2	53	10·7	50
54	14	16·0	18	13·1	23	11·4	27	10·1	32	9·6	38	9·5	45	10·3	50	11·7	54
56	13	17·8	15	14·5	22	12·6	26	11·0	31	10·4	37	10·2	44	10·9	49	12·2	56
60	13	21·6	16	17·5	21	15·1	24	13·1	29	12·1	35	11·7	42	12·1	47	13·4	60
64	12	26·0	15	20·9	20	17·9	23	15·4	28	14·1	33	13·4	40	13·6	46	14·7	64
66	12	28·4	15	22·8	19	19·5	23	16·6	27	15·1	32	14·3	39	14·3	45	15·3	66
70	11	33·7	14	26·9	18	22·9	21	19·4	25	17·5	31	16·2	37	16·0	43	16·8	70
75	10	41·1	13	32·7	17	27·7	20	23·2	24	20·7	29	19·0	35	18·3	41	18·8	75
80	10	49·7	12	39·3	16	33·1	19	27·6	23	24·4	27	22·1	34	20·8	39	21·1	80
85	9	59·3	12	46·8	15	39·3	18	32·5	21	28·5	26	25·5	32	23·7	38	23·6	85
90	9	70·1	11	55·2	14	46·2	17	38·0	20	33·1	25	29·3	31	26·8	36	26·3	90
95	8	82·1	10	64·6	14	53·8	16	44·0	19	38·2	23	33·6	29	30·3	34	29·3	95
100	8	95·5	10	75·0	13	62·4	15	58·0	18	43·8	22	38·3	28	34·1	33	32·6	100
110	7	126·6	9	99·0	12	82·1	14	66·4	17	56·8	21	49·0	26	42·8	31	40·0	110
120	6	163·7	8	127·8	11	105·6	13	85·0	16	72·3	19	61·7	24	53·0	29	48·8	120
130	6	207·6	8	161·7	10	133·3	12	106·8	14	90·4	18	76·6	22	65·0	27	58·9	130
140	5	258·7	7	201·3	9	165·6	11	132·3	13	111·5	16	93·9	21	78·7	25	70·5	140
150	5	317·7	7	246·8	9	202·8	10	161·5	12	135·7	15	113·7	20	94·5	23	83·7	150
160	5	385·0	6	298·8	8	245·2	9	195	12	163·2	14	136·2	18	112·3	22	98·7	160
180	4	547·0	6	424	7	347	9	275	11	229	13	190	17	155	20	134·2	180
200	4	749	5	580	7	474	8	375	10	312	12	257	15	207	18	178	200
220	4	996	5	770	6	630	7	496	9	412	11	338	14	271	16	231	220
240	3	1292	4	999	5	815	7	642	8	532	10	436	13	348	15	294	240
270	3	1837	4	1420	5	1158	6	908	7	552	9	615	11	488	14	410	270
300	3	2519	3	1945	4	1586	5	1245	6	1028	8	338	10	662	12	553	300

(2) *Range.*—The scale shall include either directly or by means of adjustments for various grades, a range from 0·003 to 3 foot-candles.

(3) *Constant.*—Before and after making a series of outdoor tests, the constant of the scale shall be verified at least at one point on the scale between 0·05 and 1 foot-candle against a sub-standard. If an electric accumulator is used, it shall have been run, after charging, for not less than 15 minutes.

(4) *The Lamp* shall be tested (together with the electric battery, if any, and any controlling resistance or measuring instruments) at about mid-point on the range for 15 minutes continuously without showing any appreciable change.

(5) *The Angle of Incidence* (that is, the angle between the direction of the ray of light to be measured and the vertical) shall be measured to 2 degrees by suitable means.

B. *Requirements for a Candle-Power Photometer :*

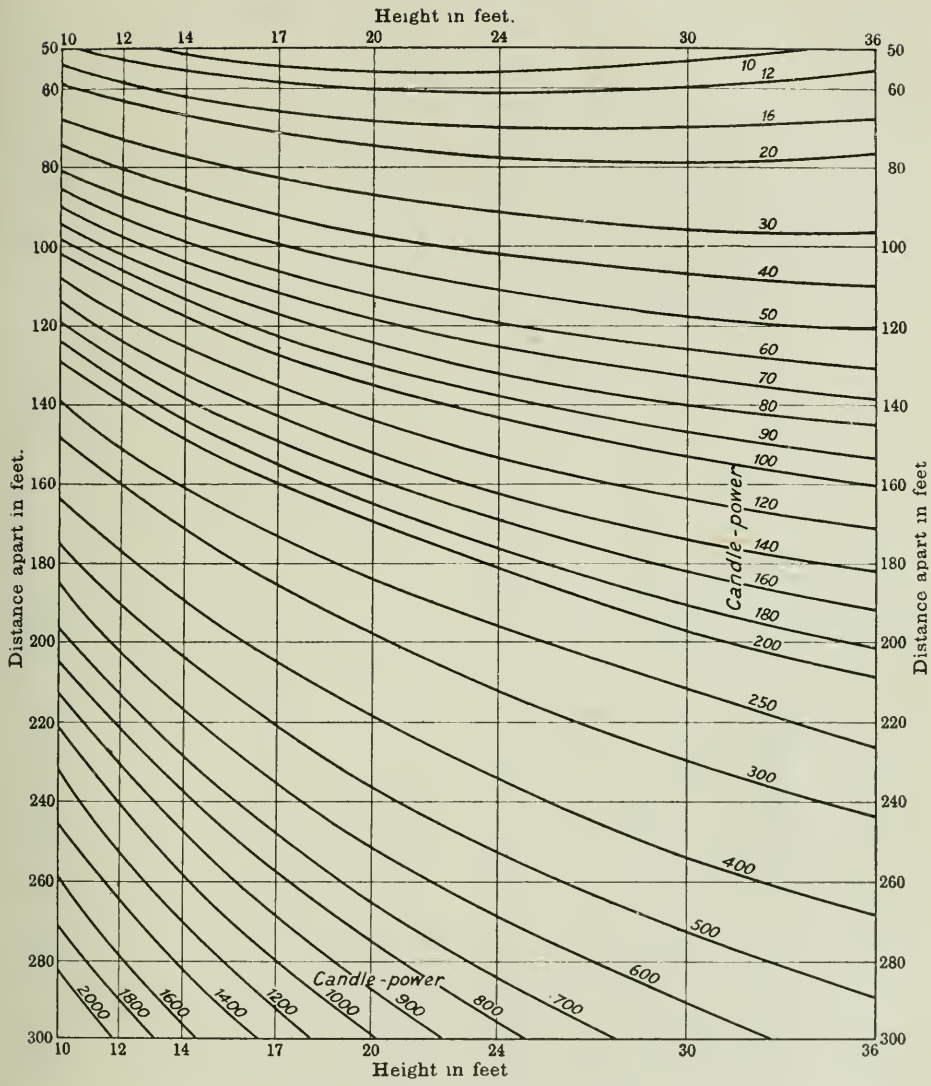
(1) *Stray Light* from neighbouring lamps, buildings, and sky shall be excluded.

(2) The height of the test-screen from the ground is immaterial.

C. *Requirements for an Illumination Photometer :*

(1) The test-plate, if forming part of the photometer, shall be so arranged that it may receive the sum of the illuminations of neighbouring lights without obstruction.

(2) The test-plate shall be free from polish or glaze, and the photometer shall be tested in a laboratory for variation



Graph of Mr. H. T. Harrison's Table.

from the cosine law. Up to the angle of incidence of 60 degrees this total variation shall not, under working conditions, exceed 10 per cent.

(3) Provision shall be made for holding horizontally, and at a height of 3 ft. 3 in. above the ground, the test-plate which receives the light to be measured.

Discussion.

Mr. A. P. Trotter remarked that as the paper had been for some time in the hands of a good many of the members of the Illuminating Engineering Society, and of the three other institutions invited to attend, and as it had been announced it was not to be read, he intended to make a few short remarks before the discussion opened.

One of the objects of the Society which he was addressing was to study and develope the use of artificial lighting. The members of the three institutions who were invited there desired to improve the standard of street lighting. The paper did not contain anything that was original; it might contain something which was new to those who had not taken part in the Committee which had been sitting for such a long time, but such novelties as it did contain were nothing more than those which had been discussed already by that Committee. The paper was frankly controversial; its object was to stimulate discussion rather than to indicate conclusions. He could not help having his own ideas, and might probably have given them prominence in the paper. At the same time the whole object of it was to produce further discussion than could have been given to it at the Committee.

It was desirable, on the other hand, that the scope of discussion should be restricted somewhat. The whole subject of street lighting covered an enormous ground; for example, the nature of the illuminant was quite outside their consideration. They were there to endeavour to promote the definite specification of street lighting, and if anybody had a favourite kind of lamp or reflector, or a conviction that the lamps should be many and small or large and few, what they had to consider was whether the specification should or should not exclude such a proposal. Such proposals could be discussed for many evenings, but the chief point before them was the specification, or rather the clauses upon which the specification should be based, for it did not pretend to be a complete specification. The paper admitted that a very large proportion of the street lighting, probably 80 per cent, must be defined and measured as heretofore by candle-power. If anybody had any other mode of dealing with those low classes of illumination, it would be interesting to hear of it, because the Committee could not see any way of doing it except by candle-power.

The higher grades of illumination were really those which he wished to discuss, and the first question was: Should the candle-power, the number, the spacing, and the height of the lamps be specified, or should they define the result, namely, the illumination received, and having defined the results leave the details to the competitive skill of contractors, and rivalry and ingenuity of inventors; to give a free hand, and not to say how it should be done? With certain reservations which were mentioned in the specification, and which borough surveyors would have to look after, namely, the suitable placing of the lamps in the streets with regard to traffic, the avoidance of glare, and matters of that sort, it might be that candle-power would be chosen as a basis; but if any group or body of engineers decided that candle-power was to be the basis, then he was afraid new specifications would have to be framed, because the one put forward was confessedly based upon illumination.

But if the illumination basis was accepted, the next question arose: Should the minimum illumination upon the horizontal plane be a criterion? And it should be quite understood that even if that was accepted, the method of measurement was left quite open by the specification. It did not say

that if they took the minimum illumination upon the horizontal plane as the criterion that that illumination should be measured directly with the illumination photometer. He, Mr. Trotter, should prefer to do so, and thought that Sir William Preece, who did it many years ago, was quite right; but if anybody wanted to use a candle-power photometer, as was done in Manchester, and from those candle-power measurements to deduce the illumination upon the horizontal plane by calculations, the specification suggested it might be done. He had endeavoured to explain in the paper how the rest should be done, and had given arguments for and against these proposals, and if the discussion removed the objections which were held by some engineers, the settlement of the remaining clauses of the specification should give no serious difficulty. Some of the clauses were rather beyond the scope of a scientific society possibly, but they had at the meeting of the Committee the valuable assistance of several borough engineers and surveyors, and it was those people who would eventually call for the street lighting, and it was very valuable to get from them the clauses which they thought should be put into such a specification. The whole question of taking illumination as the basis presented difficulties to those who had been accustomed to candle-power work, and the acceptation of the minimum illumination caused further difficulties to people who had not carefully and experimentally considered it. It had been suggested by some that if minimum illumination was taken as the basis of the specification for a street, one would have a lower illumination. He did not think that was the case, because he knew of no street of a moderate illumination which did not contain a very large diversity factor. It was only when they came to very powerful illuminations, as in the two streets described in Manchester, that one got a small difference between the maximum and the minimum. He did not think that any dioptric arrangement was likely to be invented which would so distribute the light uniformly over a street that they would be able to get a low diversity factor with a moderate illumination.

One striking part of the paper, he thought, was the record of the work done for the Committee by the borough engineers and surveyors. They had examined a large number of streets, and had scheduled them into three groups, excluding the very brilliant lighting of Oxford Street and Regent Street. Some of the streets were afterwards measured by a photometer, and it was found by making a list in order of merit from the photometric measurements of the *minima* that the grouping was exactly those which the borough surveyors had judged by eye; it further showed that the *maxima* were all over the place. It was when the *minima* were put down in order of merit that the very great illumination came out, and it convinced him that the highly experienced men looking at street after street were unconsciously influenced by the minimum illumination they were discussing, and it was on that basis that they grouped the streets into various classes.

In conclusion, Mr. Trotter asked that the discussion might be treated on as broad lines as possible. There were, no doubt, many engineers of great skill who thought they properly understood the lighting of their own particular district, but the specification (if it was going to be any good) must be a specification practically for the use of the whole country, and it was therefore very important that they should try to get unanimity if possible, or at any rate a large majority, to agree to a specification which could be used in all of the larger towns of this country.

Mr. W. H. Patchell said that the last meeting of the Committee had shown that they could not come to any unanimous decision, and that there were three courses open to them, one was to coerce objectors, the second was to modify the specification, and the third was to educate people up to it. They had come to the conclusion that if they could get the matter aired

on neutral ground they would probably be able to take the third course.

He was very glad to be able to take this opportunity of thanking the councils of the three institutions concerned who had given permission for the material collected in the course of the investigations to be thrown into the form of a paper. Our thanks were also due to the Illuminating Engineering Society for their permission, and especially the opportunity of discussing this paper, and particularly were our thanks due to Mr. Trotter for writing the paper. The Committee had been exceptionally fortunate in having among them Mr. Trotter, as he had made illumination his hobby and a labour of love for the last thirty years, and if the discussion on the paper enabled us to come to a unanimous decision on a draft specification it would be in a very large measure due to Mr. Trotter's efforts. He gladly took the opportunity offered by the Chairman, and formally proposed a very hearty vote of thanks to Mr. Trotter.

One of the most striking things in the paper was the report of the surveyors. It was all very well for a London man to say he wanted a street to be illuminated like the Strand or Regent Street, or some part of Whitechapel, but it was difficult, without measurement of illumination, to translate the Strand or Regent Street as a standard of reference for, say, Newcastle. The schedule of measurements showed that the surveyors knew their business absolutely; he thought perhaps even better than they themselves realized; they knew exactly what they wanted and when they got it!

While the investigations were proceeding the Committee had thought it advisable to get the feeling of the police on the matter of illumination; also of the motor drivers, to see what they had to say about it. He, Mr. Patchell, had written to one of the leading members of the Royal Automobile Club, whose reply was to the effect that the darkest street suited his purpose best, for so long as he was driving in a dark street or in the country he was perfectly happy with his own head lamps, but when he came into a brightly lit street he was dazzled and objected to it. In fact, it was easy to see that he would prefer concealed lighting, which was now so commonly used in up-to-date shops, and however gladly those interested in the sale of gas or electricity might welcome the suggestion of lighting streets in this fashion, he was afraid that those who would have to pay the bill would find such a scheme impracticable.

There was one report made to the Committee which the author did not include, that was the report made by Prof. J. T. Morris on a series of tests to show the agreement between illumination of a horizontal surface and that calculated from direct illumination from several sources. The result of several tests gave a calculated maximum deficiency of 22 per cent and a mean deficiency of 11 per cent. In one case there was a calculated excess of 3 per cent; this was an instance of low illumination, and brought out the difficulty of measuring very low illumination on a horizontal plane, because of the stray light effect. He hoped this point would be further dealt with in the discussion.

Mr. F. W. Goodenough said that he should like to be permitted, as Chairman of the Council of the Society, to second the vote of thanks which Mr. Patchell had moved in his very interesting speech.

They were very fortunate in having had a paper from such an authority on the subject of photometry as Mr. Trotter. The question was undoubtedly a rather controversial one. The author had said that the Society existed for studying and developing the use of artificial illumination, and to raise the standard of artificial lighting in all directions in which artificial illumination had to be used. As Mr. Mr. Patchell had remarked, the Society was neutral ground for the discussion of those questions, quite irrespective of what illuminant was used for producing the illumination, and that was a point he was sure they would all bear in mind in the discussion on the paper. They were there to try to find a satisfactory specification whereby the public

might be sure of obtaining the type of illumination, and the resultant illumination of their streets which they desired. They had to discuss to what extent the draft specification put before them in Mr. Trotter's paper lent itself to that object, and whether any improvement could be made in it to bring it nearer to the ideal.

He had much pleasure in seconding the vote of thanks, which he was sure they would accord with acclamation, and to which he would ask Mr. Trotter to respond at the close of the discussion, which he then declared open.

Mr. Haydn T. Harrison agreed with the author that lighting authorities should settle what it was they wanted to buy, a question which so far had never yet been satisfactorily settled. They had got into a groove, and generally only specified that a street so many yards long should have so many lamp posts supporting a certain class of lamps, but whether the lamps gave anything in the way of light or illumination was apparently a matter of no importance whatever.

The object of the specification was to reduce to an agreed basis the result, whether it be candle-power per lamp, horizontal illumination, or direct illumination. He did not object to the basis of illumination, but to the basis of measured minimum illumination. The minimum illumination in certain classes of streets was so low that they could not conveniently measure it. It is true they had to measure illumination in order to ascertain the candle-power, but not minimum illumination; and there was a very large number of streets where they could not, under the open-air conditions, measure the minimum horizontal illumination accurately. Thus it was necessary to measure the illumination at a convenient distance from the lamp, and from that calculate the minimum horizontal illumination. For instance, the majority of streets were lighted by 50 candle-power lamps on posts 10 ft. to 12 ft. high—quite a usual height—and 50 yards apart. If the specification that had been drawn up by the Committee had stated the minimum illumination of streets below ·01 they would have classified a very much larger range of streets than at present come into the illumination specification. They would notice all the "A" streets had ·01 foot-candles, and beyond that they gave a clause which allowed one to calculate what the minimum illumination would be by measuring the candle-power. If they decided to have a horizontal illumination basis as a specification of what the average streets were to be, it would have been such a low horizontal basis that it would have been liable to error in measuring direct; for this reason the Committee had come to the conclusion that the most badly lighted streets on which they could give a horizontal basis of illumination was ·01. Below that point the basis should be a measurement of the candle-power, provided that the measurement was made at an angle which would reach the point of minimum illumination. This was one way of dealing with it, but the speaker would like to have scheduled the low horizontal illumination as calculated from the c.-p. measurements, which would be accurate, because they would be measuring the candle-power of the lamps at a much higher degree of illumination, and the error for extraneous light would be appreciably small.

Regarding the more highly illuminated streets, he quite realized that as time went on the lighting of all streets would naturally increase on account of the demands of increased speed of traffic, and on account of the demands of the people. The author had given a criterion of the problem in one of his clauses, namely, that at the present time illumination of the streets was governed by how much money could be taken from the rates for the purpose of street lighting, and naturally in London, wealthy boroughs and councils were able to devote much more money to street lighting than was the case in the country. If the specification were to become general, it would enable people to see that they got the proper illumination for the amount of money they had at their disposal. He could quite understand the motorist's preference for the street

with no lamp at all, but the motorist would not have made that remark if he had been thinking of a street in which the lamps were placed at distances, say, of 50 ft. Small candle-power lamps 50 ft. apart would be the ideal lamp for the motorist. What they objected to was the passing from a position of darkness to a position of extreme brightness. The minimum horizontal illumination specification got over the difficulty, as it would ensure a street being illuminated up to a certain minimum amount.

This was not the first attempt at a specification for street lighting. Other countries had considered the problem, and dealt with it on much the same lines, namely, by horizontal illumination at a specified height above the ground. At the discussion on a paper read this year before the Institution of Electrical Engineers the question of the height of measurement above ground level was raised. Nearly every street photometer which he had used had been arranged for measuring at a metre above the ground level, which was the most convenient height; and another advantage of this height was that it was half-way between the ground level and the objects looked at, such as the faces of pedestrians or the numbers of houses. He thought that if a lighting authority gave a satisfactory horizontal illumination at one metre above the ground level, they would certainly give a very much more satisfactory horizontal illumination on the ground level. For the reason that if they had ·01 foot-candle at one metre above the ground with the average height of post they would probably get ·02 on the ground. The main difference of opinion on the specification lay between whether one should measure the candle-power of illumination. He had been in the habit of measuring the candle beam by putting the photometer in the most convenient position for measuring, and then calculating the candle-power and minimum horizontal illumination afterwards. His reason was that in all street measurements at least 90 per cent had to be done in places where the candle-power of the lamps rarely exceeded 50 to 100, and to measure a lamp of 50 c.-p. at 100 ft. from it was certainly to court inaccuracy; he would prefer in this case to measure at a distance of 20 ft.

As far as the question of measurement in the lower grade streets was concerned, the specification now presented no difficulty. The contractor who was asked to tender for the work, and the engineer or surveyor who wished to satisfy himself that the work had been done properly, were all able to carry out such tests. Taking the specification as a whole, he considered that it would be extremely difficult for any society to improve upon it; therefore those societies which had joined together in drafting it deserved the thanks of both their members and the public.

Mr. R. Watson, expressed his thanks to the Council of the Illuminating Engineering Society for the invitation they had extended to take part in the discussion of what was an interesting topic—street illumination—and also for the opportunity of meeting friends engaged in the same work, although representing another phase of it.

Mr. Trotter's interesting paper was a fair presentment of the Proceedings of the Joint Committee which had been meeting for a considerable time to consider and draw up clauses for inclusion in the Standard Specification. Although Mr. Trotter advocated the adoption of the specification as it had been drafted, he was bound to admit that his treatment of the subject had been a very fair and impartial one. The fundamental basis of the specification now drafted was, that street lighting should be judged by the minimum illumination obtained at a point in the street, that point being usually midway between the lamps, and that that illumination, expressed in foot-candles, should be measured or computed as received on a test-screen placed horizontally at a height of 3 ft. 3 in. from ground level. No great objection had been raised in the Joint Committee to street tests, nor to the acceptation of the minimum illumination as

the basis of a contract, with one foot-candle as the unit; it was when they came to the question as to how that minimum illumination should be appraised that there were apparent differences of opinion. The draft specification clearly proposed that street illumination should only be appraised by measuring or computing the illumination in foot-candles on a horizontal plane, and that all results should be expressed in horizontal plane foot-candles, and it was with that stipulation that some of them felt bound to disagree. Those who represented the Institution of Gas Engineers, and possibly one or two other members of the Committee, did not consider that the computation and expression of illumination values in horizontal foot-candles afforded any true guide to the actual illumination received and used by people—pedestrians, drivers, and others—in the street; nor did they consider that those values equitably represented the comparative merits of lamps of different polar distribution or of different heights and location. Unhappily, the representation of the Institution of Gas Engineers on the Committee was numerically very small—two or three only out of a large Committee—and their views were therefore not reflected in the draft Standard Clauses. His own opinion was, strongly, that the illumination actually and chiefly used in the streets, and which therefore municipalities were, or should be, "out to buy," was of the direct-ray character, and that therefore the candle-power of any lamp or its direct-ray foot-candle equivalent at the point of minimum illumination was of the greater importance. For the purpose of seeing, recognizing, or avoiding collision with other people or vehicles, houses, walls, and the like, they used the direct light which was falling upon them; even when a person was approaching them from a lamp, his figure was silhouetted against the direct-light source behind him, and contact was avoided because of that fact. This was surely the case with motor or other vehicle drivers, who rarely looked upon the ground, being more concerned with what was immediately in front of them. They did not particularly interest themselves with the ground illumination; still less with horizontal plane illumination at a height of 3 ft. or 4 ft. above ground surface.

Superintendent Bassom, of the Public Carriage Department of Scotland Yard, on his attendance at one of the meetings of the Joint Committee alluded to by Mr. Trotter, stated that cross-traffic at street junctions always required great consideration. One could not conceive that anything but direct light would be of service to a driver if he wished to avoid collision in such a case. Under ordinary street conditions one rarely looked upon the ground, and even if one did, it was a question whether less use was not made of the horizontal plane illumination from several lamps than the light from the lamps in front shining on the ground and being reflected in direct rays to the eyes. The purpose of illumination in the streets was quite unlike that in halls or rooms, where reading, writing, or work were in question, and where the diffused light from ceilings and walls constituted an important factor.

Proceeding, Mr. Watson said that, apart from their views that the horizontal plane method of appraisement did not apply to the chief uses of street illumination, it was admitted by Mr. Trotter that, in the case of 80 per cent of the lighting of the country, it could not be used at all, the reason being that in some streets and roads the lamps were too widely spaced to permit of accurate minimum horizontal illumination tests, and in that he was glad to say he was corroborated by Mr. Harrison. In the majority of provincial streets, he was afraid, that would long be the case, since the funds of the municipalities would not allow them to be as liberal in pubic lighting as they could wish. In these cases (80 per cent of the whole) candle-power measurements were in accordance with the specification to be adopted. In other words, the appraisement and expression of the illumination obtained were to be virtually in direct foot-candle values, and Mr. Harrison had told them that

it was illumination which was to be measured whatever the distance might be. Hence the desired uniformity and standardization of illumination methods of computation were as far away as ever. In the meantime the specification legislated for only 20 per cent of the lighting of the country, and demanded computation by methods as to which there was still some fair diversity of opinion, not only in this country, but in America and on the Continent. In America lighting authorities, both gas and electric, believed in the appraisement of street illumination on the basis of the light received on a screen placed perpendicular to the light ray. The Association of Gas Engineers in Austria-Hungary, according to Prof. Strache, did not even believe in the specification of minimum illumination, and were in favour of the stipulation of candle-power for contracting purposes.

The replies received to the queries advanced by *The Illuminating Engineer* some time back were various, and to some extent conflicting. Four or five of the eleven replies were against street tests altogether. A number of the replies (principally from the electrical industry), dealing with horizontal plane methods of computation, wanted either confirmatory laboratory tests or tests of vertical illumination, apparently considering the latter of importance. In other cases a statement of the maximum and mean as well as the minimum illumination was required. The latter was the case of the German Electrical Association, whose conclusions, by the way, were arrived at by a comparison of two systems of testing only, namely, the horizontal and vertical plane (not direct-ray) methods of testing. The vertical plane under a lamp had some of the defects of the horizontal plane used at a distance from the lamp.

Moreover, the horizontal plane computation of illumination values was not a fair and impartial method of appraisement, since equal justice could not be done nor unfair penalization avoided in the case of lamps of different polar distribution, and with different heights and location. It may, for instance, be deemed advisable in many cases to use closely spaced lamps of moderate height for the purpose of ensuring well-distributed and diffused illumination. By direct-ray testing evidence of the value of such a scheme would be obtained, but by the horizontal plane method, with a test-screen not much lower than the light source, the light would, by reason of its obliquity, give very low readings. On the other hand, a light source raised to a greater height, while not giving the particular illumination desired, would yield higher figures because the light rays coming from above were virtually approximating to the direct-ray character. In speaking of lamps of moderate height, low lamps were not necessarily meant, so that glare (if any) need not be considered. He did not agree with Mr. Harrison that the usual height of a lamp was 10 ft. He had never bought a lamp column under that figure, and when the height of the lantern was added, it came to nearly 12 ft. Lamps used for good illumination were not much less than 15 ft. or 16 ft. in height, and were therefore sufficiently high above the line of vision. Apart from that, however, Superintendent Bassom, of Scotland Yard, told the Joint Committee that he did not think that the glare in itself was the cause of accidents, although sometimes given as an excuse.

It was interesting to note with regard to horizontal plane testing that, if in starting from a midway point between two lamps, the test-screen was traversed towards one of the lamps, the rays became more and more direct, and therefore less affected by the Cosine Law. Hence in the vicinity of the lamps there was little difference between horizontal and direct-ray readings, although the values at the midway point were altogether different, which seemed certainly to suggest that the horizontal method was inconsistent. That was borne out by and accounted for the large diversity factor disclosed by tests made in this way. Table No. 1 in the Paper showed one as high as 67, a diversity of which the eye was not conscious because, as he believed, it used direct rather than horizontal plane illumination. If two curves of

horizontal plane and direct-ray illumination obtained between two lamps were plotted out and contrasted, the diversity differences were clearly shown, and he would give as an example a test of two lamps each yielding, say, 1,000 c.-p., where at the midway point the combined horizontal plane illumination was 0·086, and the diversity factor 25 ; whereas the single minimum direct-ray reading was 0·181, and the diversity factor in that case only 15. He was inclined to think that the latter more nearly accorded with ocular experience, and therefore suggested that direct-ray illumination was principally used. Even if the horizontal plane test of illumination was generally accepted, there would appear to be differences of opinion among its advocates as to its application. The writer of the leader in *The Electrician* of March 14th, 1913 (probably reflecting the views of many of the readers of that journal), saw no reason for the specification of any height at all, " considering it more sensible to take the street level. Horizontal illumination was required for showing obstructions on the street surface, not objects 3 ft. 3 in. above the surface." The leader went on to say " that it was vertical illumination that was required for discriminating objects at a height, such as houses, trees, &c.," and the " &c." might be taken to include vehicles and people. It was an interesting fact that in the recent comparison of two systems of lighting in Manchester they had the testimony of several gentlemen representing various interests agreeing that, as far as the eye could judge, the illumination in the one case was as good as the other ; and street photometer tests of the horizontal plane illumination were required to suggest any difference. In other words, it would seem that, if the observers were lying on their backs, and their eyes occupying the position of the horizontal screen. they would only then become conscious of the horizontal plane differences disclosed by the street photometer. So far as reflection effects were concerned, the direct-ray instrument, in which the comparison screen could be placed side by side, was more likely to yield true results than the horizontal plane photometer, where one screen was on the outside, and the other inside the box.

In connexion with the effect of extraneous light in street tests generally, Mr. Watson said he would like to refer to some tests that had been made for the Joint Committee. One member of the Joint Committee was good enough to furnish some data making comparisons between the measurement of illumination (0·0188 foot-candle) received from several lamps on to a horizontal plane test-screen, and measurements of the direct-ray light received from each of the several lamps, and subsequently corrected to the horizontal basis and added together (0·0147 foot-candle). It was interesting to note that the latter differed from the former by as much as 22 per cent, although there might be other tests where the differences were less. In view of the fact that it was admitted that direct-ray tests were less affected by the reflected light than were horizontal plane tests, these experiments suggested how difficult it was to get comparable and fair data with a horizontal plane test-screen. There was another set of experiments, made with an illumination photometer, where first of all, the illumination was received and measured at right angles in the usual way, and then in the same way with a 10 in. $\times$ 1½ in. tube attachment, in order to get the net illumination—that was to say, eliminating the reflected light. Those tests showed that the stray illumination with the direct-ray instrument was not more than 1·6 to 5·7 per cent. While those figures showed that stray light had an effect, they also proved that an instrument could be made to eliminate adventitious illumination.

A further advantage was the fact that the higher readings of the direct-ray instrument tended towards accuracy of result, and to lessen the possible errors in connexion with colour troubles. One point in particular should be mentioned—that was the disadvantage of appraising street illumination by values such as those of the horizontal plane method, which

ran, or might run, into small figures. In view of the admitted possibility of errors, due to the personal equation, the instrument, and its usage, the higher the values the better. Otherwise, contracts would have to provide for a sufficiently large margin between the actual and the expected minimum street illumination before fair monetary penalization could be imposed. He was inclined to think that the difficulties of the horizontal plane test in dealing with several lamps at once had been a deciding argument with some, but surely it would not be difficult with the direct-reading instrument to contrive to make it sufficiently workable so as to facilitate quick reading of two or three lamps in succession. He believed that in the expression of those opinions he was voicing the views and opinions of the great majority of the members of the Institution of Gas Engineers, and certainly those of the Council. They had no wish to be in any sense inappreciative of the work which had been done by the Joint Committee—work which was certainly of great value; but, holding the views they did, they asked at least that clauses should be included giving the alternative of reading the specification as dealing with minimum illumination computed and expressed in direct-ray foot-candle values.

The form of the Specification with such an alteration would not be materially altered. The classification and grading of the streets were good. To fit in with the alternative clauses all that might be necessary would be to ascertain the direct-ray minimum illumination in the streets which were taken as examples for the purpose of the classification.

Mr. J. G. Clark said it had been a great pleasure to him to read the paper. Mr. Trotter's work in connexion with lighting problems, especially those relating to public thoroughfares, was so well known, and there was very little doubt that when the history of recent illuminating engineering developments came to be written, it would be seen that his work had played a very important part.

On p. 246 Mr. Trotter mentioned that "it was probable that some of those who disagree with the proposal to measure illumination directly on a horizontal plane had never used or perhaps seen a photometer for that work." He (Mr. Clark) said he found it difficult to agree with the proposal to measure horizontal *minima*, but he did not fall into the category of "some of those who disagreed" alluded to by Mr. Trotter. The department to which the speaker was attached, not only had, but used, eight of the modern types of photometer, so that his remarks were based upon some little experience. He thought he might safely say that his "Trotter" photometer was a real "old soldier," and would probably vie with any photometer in existence in regard to the amount of work that had been done with it.

Hitherto contracts for public lighting had been based on the measurement of candle-power—that is, direct illumination—and as one who had had considerable experience, he would like to say that that method had the very important merit of being capable of exact definition, and conduced to a complete understanding between the contracting parties. Any one who had had experience in specifications knew how important exact definition was. One looked, therefore, for some special advantages in a new method before adopting it. While admitting the usefulness of measurements of horizontal illumination, Mr. Clark was unable to say that they were capable of such exact definition as the measurement of normal or direct illumination at a specified angle (*i.e.*, of course, candle-power), and his experience had led him to believe that horizontal illumination should always be subordinated to the more exact method.

In reviewing the Author's case for the horizontal method, Mr. Clark said that, on p. 6, it was stated that there was a great saving of time by adopting the non-mathematical horizontal method. He had never experienced the mathematical tediousness alluded to by Mr. Trotter—a good slide-rule did the work quite easily. The large number of observations necessary to find the

horizontal *minima* would, to him, be far more fatiguing than a simple calculation on a slide-rule. The Author stated that the horizontal minima was extended over a considerable area, and therefore was easily found. Although that might be true in a number of cases, there were still many others where difficulty might arise. If one divided a thoroughfare into several tracks, all parallel to the axis of the street, and explored the illumination along the centre of each of them, it would be found that the minimum was sometimes in one track and sometimes in another, depending on the disposition of the light sources; in fact, his experience had led him to believe that a special exploration or survey was necessary to find the minimum, and even then, owing to its usually low value, it would, he feared, be difficult to be sure of being within, say, 10 per cent. It would, therefore, seem that if horizontal *minima* were to be taken for evaluation purposes, a definite position ought to be specified to avoid the perambulation. Mr. Clark showed some slides illustrating this point.

Proceeding, Mr. Clark said that the Author dismissed the question of reflection from walls as unimportant. It may, however, be important sometimes, especially if the wall was glazed. Regular reflection from the windows of the houses was sometimes a really serious matter if not guarded against. It was these little things that might *sometimes*, though *not always*, happen, that left so much room for misunderstanding where the horizontal *minima* was taken as a basis. Shop lighting also interfered with accurate measurements of horizontal *minima*, although this difficulty could be overcome by deferring the work until after closing-time—a course, by the way, that would not be welcomed by those who had to do the work. Mr. Trotter had admitted certain limitations of the horizontal method, owing to the high proportion the extraneous light would bear to that due to the sources themselves. He, however, had not found it difficult, in taking candle-power measurements, to narrow the field of view to avoid errors due to haze; but atmospheric conditions were very important, and he noted that a clause on that point had been inserted in the proposed specification. The Author also admitted that difficulties occurred where the angle of incidence of the ray on the test-plate was large, and pointed out that the specification permitted the test-surface to be set normal to the ray of each lamp separately, and the result converted to the horizontal basis by adding the horizontal components of each of the lamps illuminating that point. Seldom less than three lamps would have to be dealt with in determining a horizontal minimum value, and this, together with the necessary perambulation to find the minimum, would make the work of manipulation and calculation very considerable indeed. Mr. Clark's experience had led him to believe that the conversion of normal illumination to the horizontal component by calculation was not always reliable. A comparison of calculated and measured horizontal values would sometimes disclose discrepancies. Mr. Harrison had mentioned that similar differences had been reported by Prof. Morris.

Mr. Clark thought Mr. Trotter's strongest argument in favour of horizontal *minima* was the comparison of these *minima* as shown by photometer, with the findings of the Surveyor Members in their report. The agreement alluded to in the paper could, he thought, be easily overrated, and it was probable that other factors than the horizontal minimum illumination influenced their judgment. For instance, anything from ·011 to ·025 foot-candles inclusively were grouped into Class "B," whereas ·027 to ·034 foot-candles were grouped into Class "C." The agreement was certainly interesting, but there was sufficient latitude to cause one to think there must have been other factors, such as diffusion, glare, &c. They must not forget, too, that the Surveyor Members' judgment was probably influenced by the illumination of the surface of the street, and also the vertical surfaces, walls, &c. The Author was, no doubt, aware of the influence of the vertical surfaces—in fact, he had mentioned in

his paper that: "It was true that a street with light coloured houses seemed to be better lighted than when the buildings were dingy."

That brought them to the question of the height of the test-surface. As that bore an important relation to the height of the lamp, it did not appear to be sufficient to say that the standard height above the ground should be a metre. It would seem only fair that a special height for the test-surface should be stipulated for each height of lamp. It was true that this would complicate matters, but that was just the difficulty he found with the horizontal method; unless the conditions were made flexible, equal justice would not be done to the various types of installation, and unless equal justice was done ,there was a risk of penalizing unduly what might be a very good system of lighting, as, for instance, low-candle-power units on short posts. One of the terms that had come into very common use in general illuminating engineering work was "the working surface." They had heard a good deal of that. It was a very useful term, and one that could, as a rule, be construed under the various conditions. One simply ascertained the kind of work going on, and asked the question, "Upon what surface was the work done?" The question was asked when exploring the illumination of libraries, schools, workshops, offices, &c. If the same question was applied to street lighting, where did it lead? He (Mr. Clark) could not see that it pointed to the horizontal surface, such, for instance, as would be represented by the crown of a pedestrian's silk hat. If one held a letter or a newspaper in a reading position, it was almost certain to be vertical or normal. A person walking along a street represented a peripatetic vertical plane.

It therefore seemed to him that evaluation of street illumination by direct-ray methods at some specified angle was to be preferred to horizontal *minima* for the following reasons:—

1. Greater accuracy.
2. Equal justice to all systems, and therefore not penalizing unduly any particular system.
3. Expeditiousness.
4. More precise definition of terms.
5. It could be applied to all systems of lighting, and therefore made uniform, *no alternative methods being necessary.*

In criticizing the horizontal method, Mr. Clark said he hoped he had not under-rated its value. He thought it was extremely useful in setting out an installation. Contour horizontal illumination curves should always be taken into account in arranging the spacing of lamps, but in defining the terms of the contract such curves should, he thought, be subordinated to the more precise method of normal illumination measurement. He had always felt that the question of diffusion, apart from illumination, had an important bearing upon popular ideas of street lighting, and was one that might be considered with advantage. It was probably a difficult question, but it occurred to him a day or so ago that a measurement of shadow density would throw some light on the matter. He had therefore had a simple piece of apparatus made up, consisting of a square wooden box open at each end, the box being $3\frac{1}{2}$ in. square and about 12 in. long, having at the end a fixed translucent piece of paper. Inside the box was a movable perforated screen, carried on a spindle which passed along to the end of the box, and so varied the distance between the fixed screen and the movable screen. The perforated screen was formed of a piece of fine gauze. The image of the gauze was thrown on the fixed translucent screen, and by moving the perforated screen and increasing the distance from the fixed screen, the shadow ultimately disappeared; and he thought the variation in distance might in a way be a measure of the diffusion—that was to say, the smaller the distance necessary to cause the shadow to disappear, the greater would be the diffusion.

In conclusion, Mr. Clark said that, as a student of illuminating engineering, he would like to express his indebtedness to Mr. Trotter, for, like many other students of the science, he had often found it beneficial to listen to Mr. Trotter's remarks and to read

his papers from time to time, and he had come to look upon Mr. Trotter as one of the leaders in that branch of work.

Replying to a question of Mr. Haydn T. Harrison, Mr. Clark added that the curves he had shown referred to horizontal measurements—in one case derived from two lamps, and in the other three lamps.

Mr. Franklin Thorp thought the Society was going to do very excellent work for the general public in calling attention to the really important points in correct illumination. But gas engineers felt that the horizontal illumination was not the best test, and they felt very strongly that the direct ray method was the one which they ought to use.

He hoped the Committee would also take into consideration the question of quality of light. It was interesting to note the difference in the spectrum in the light between an arc light on one side of a road and the incandescent gas or incandescent electric light on the other, and if it were possible to include some arrangement whereby the character of light could be specified he thought every one would be particularly pleased.

In connexion with the measurement of candle-power of a lamp itself, it was difficult to take that as a real test, because the distribution curve came so much into play. That was a point to which the Society had already called attention. Even if one took the mean hemispherical candle-power and plotted a curve it came to be a difficult matter to get a true arrangement when the mantle or lamp varied from the recognized standard. In Mr. Harrison's table at the end of the paper it was stated that at 70 ft. distance apart for the lamps and at 10 ft. in height it required 33 c.-p. to give the desired minimum illumination, whereas the same candle-power, or rather a less candle-power—32·6—would give the same illumination at 36 ft. high, 100 ft. apart, which in the case of ordinary things was absurd. He did not mean to say the figures were wrong, but he thought it proved that there was something wrong with the horizontal illumination test. If one took the direct ray test, which would be the light one would get upon any object, they would find it would be about 7 to 1, instead of being equal. Again, in taking the direct ray method, it did not matter whether the photometer was on the ground or a metre high, or at any other height, but it made all the difference in the world, as Mr. Harrison had pointed out, if one took the horizontal test, as at a metre height the low light is so much penalized; in fact, in the case mentioned, with lamps 100 ft. apart, and 10 ft. high, one got lamps requiring 95 c.-p., whereas at 14 ft. high it was 62 c.-p., so that there was a difference between the 95 c.-p. and 62 c.-p., whether they had it on the floor or at 3 ft. above the ground. He thought this was very important.

Mr. K. Edgcumbe said that as regarded the minimum horizontal illumination question, he was a "whole-hogger," and he had been confirmed in that opinion by reading Mr. Trotter's most able exposition. He thought nobody, after reading the paper, could possibly have any other idea but that the horizontal illumination was the correct criterion, though, as there still seemed to be a few "wobblers," he would like to draw their attention to the figure which had already been referred to on p. 250, namely, Fig. 3. He thought it should be headed 'Minimum Illumination,' instead of 'Illumination.'* That figure seemed to answer all the objections that had been raised to the horizontal illumination basis.

First of all they were told that, although it might be a very convenient way of measuring the illumination of a street, it was only a physical measurement, and did not take into account the physiological question. In fact, one of the previous speakers raised this very objection. He said he thought that the borough surveyors who had classified the streets by eye were not influenced only by horizontal illumination, but that they must of necessity have been influenced by other things, such as the illumination of the

* This alteration has been made in the text.—Ed.

houses, the vertical illumination, &c. He (Mr. Edgcumbe) quite agreed with this, and in fact thought it was the whole point. The surveyors who classified the illuminations were all men of life-long experience, and the fact that they classified the streets in precisely the order of the minimum horizontal illuminations was conclusive evidence that the horizontal illumination test did actually give the criterion that was wanted. Mr. Edgcumbe thought, further, that the table disposed of the question of the supposed difficulty of measurement. A good deal had been made of this. Mr. Trotter, however, told them that all the measurements were made without any difficulty, and yet they ranged from about six-thousandths of a foot-candle upwards.

A great point had been made of the simplification which would be introduced by measuring the candle-power direct—and he felt sure that a good many speakers thought that the specification laid down that the minimum illumination had to be measured direct —but Mr. Trotter had pointed out that this was not so, and though his (Mr. Trotter) own personal view was that he preferred to measure directly, the specification did not lay down that it was to be measured direct, whether the illumination was high or low. Continuing, Mr. Edgcumbe asked what alternative there was to the proposed specification. The other suggestion that had been made during the evening, and which might have something in it, was the direct ray minimum. At present the only specification which had been widely used was what was called the "Westminster" specification, and what a complicated thing it was. They had to give the height of the lamps, the spacing, the angles at which the candle-power was to be measured, and then had to guard themselves against all sorts of freaks by saying that the reflectors must not be curved, and so forth. All that was very complicated, and was entirely obviated if the horizontal illumination was adopted as the criterion.

Mr. John Darch considered that Mr. Trotter had given them a most valuable commentary upon the proposed Standard Clauses for a Street Lighting Specification, and had handled the details in his well-known fair and unbiassed manner, particularly so in dealing with the question of illumination *versus* lamp power as a basis of measurement. He had rightly shown that the public wanted illumination, and not lamps, for light was the commodity for which the public paid—lamps were but the means to that end. Illumination was a blessing—lamps were a nuisance. The Street Lighting Committee were, therefore, to be congratulated on adopting illumination as a basis of measurement.

But Mr. Trotter had wisely separated the lowest class of street lighting and that of country roads from the rest, and showed most clearly that in that class it was necessary to fall back upon the old system of reckoning by the candle-power of lamps. Why? because there was so little street illumination in it that the lamps could only serve as beacons. In other words, it was somewhat ludicrous to call it street lighting at all. It might be argued that such "lighting" was better than nothing, and that, at least, one had the beacon for what it might be worth. He supposed, however, that most of them knew that one could not have a beacon before the eyes without diminishing its lighting value, without blackening the gloom, and making it more difficult to see.

They had done well to have secured a basis of illumination for street lighting—it was a big step in the right direction. Nevertheless, they had not gone far enough, for illumination was but a means to an end, and that end was the eye, the act of perception. A cat could see clearly in what, to most of them, would be darkness; but no amount of illumination would serve a blind man, by which remark he meant to point out that they were not at all concerned with the amount of light that was around and external to them, but only with that which succeeded in entering the eye; and he said emphatically that no system of street lighting was worth having that did not

provide for visual and physiological efficiency.

It was a matter, therefore, for surprise that, after all that had been said and written on the personal factor and its related question of glare, it had had no consideration in the proposed Standard Clauses, nor in Mr. Trotter's paper. They had a splendid opportunity of indicating to the public what modern science and advancement had done for them, and yet they were still to be subject to the principles of illumination that were fashionable in the Middle Ages—the old lantern and the bare light stuck on a post. Indeed, their mediæval ancestors had a much better sense of proportion, for it was quite right and necessary that the feeble and harmless candle and oil lamp should be exposed, for "a candle was not brought to be put under a bushel"; but now they had committed the absurdity of engrafting a cruel modern high-power lamp on to an antiquated system of illumination for which it was entirely unsuitable. Could anything be more crude and illogical? Surely the object of lighting was the safety, convenience, and comfort of the public; something that would enable the people to see; but the actual effect of the present practice, and from which the new rules indicated no relief, was so to affect the eyesight that the actual illumination was apparently, and therefore practically, reduced from one-half to one-tenth of its photometric value.

It was only at their last meeting that he pointed out to several Members how the very dark red wall of their meeting-room, when behind a powerful lamp, was made five or six times brighter—indeed, became a brilliant red by the simple expedient of screening the light from the eye. A medical friend of his went to him a few days since, and explained that he had two powerful head-lamps on his motor-car, and was able to see a long way in the dark, but that as soon as a modern street lamp came into view he could see nothing, and might as well have no lights for all the use they were to him, and he was often afraid of running into something. Mr. Darch said that Mr. Trotter and he were discussing that very problem a short time ago, walking along Victoria Street, which professes to be well lit, and so it was as far as expenditure was concerned; but the glare of the lamps was such that they nearly fell over a heap of coals lying across the footway. (Laughter.)

He was prepared to admit that there was nothing in the proposed Standard Clauses to prevent the adoption of some scheme or principle designed to avoid the difficulties to which he had referred; but the serious thing about it was that the public and the contractor would take this as the last word in street lighting, and would naturally assume that every feature of the case had been considered, nor would the public be aware that they had been paying, and were still likely to pay, for illumination that they could not see. He therefore repeated, what he had already proposed, that Clause 3, which defined the minimum illumination for various classes of streets, should have an addendum to the effect that, where the lamps were properly screened, the photometrically ascertained illumination to be provided may be 33 per cent less. This would mean 33 per cent saving in running and much better lighting. Although he had modestly suggested but 33 per cent, he had no hesitation in saying that the advantage would be six times that, and that a shielded light of 60 c.-p. would enable one to see better than with a 200 c.-p. exposed light. That might seem an extravagant statement, but was it not a fact that it was easier to see and safer to travel when there was neither street nor shop lighting on a light night of (say, 1-500th part of a foot-candle) than with the dazzling brilliance of a Piccadilly Circus? In the Standard Clauses 1-100th of a foot-candle was given as the lowest illumination desirable. That, no doubt, was the result of very careful observation. But did they not know that what was called a moonlight night, when one could see one another's faces perfectly, was only about 1-100th of a foot-candle? Why, then, was it that the one was pleasing and everything so clearly seen, when the other, at the

same illumination, was a troublesome gloom ? The answer was Glare and the presence of exposed lights which closed the pupil of the eye and paralyzed perception.

Mr. Darch said that Mr. Harrison referred to the objection taken by motorists to the blinding effect of street lamps, and had stated that if a number of smaller lights were put in a long line they would cause no trouble to a person driving a motor-car. In his (Mr. Darch's) opinion there would be just the same trouble (perhaps not quite so bad as a single dazzling light, but it would be the same thing)—bright lights, dominating the vision, would close the pupil of the eye.

Continuing, Mr. Darch said it would be beyond the scope of his present remarks to enter into the practical details of arranging and screening the lights ; suffice it to say that it was all simple and inexpensive, and where tried had had the happiest results. It was not the nearer so much as the more distant lights that gave trouble, and prevented the nearer objects being seen, and that fact would diminish the difficulty which the orthodox street lighting engineer saw in any system of screening. And, be it remembered, that distance did not diminish the brilliance of a light.

There was another important factor in street lighting that had not been touched upon either by the Committee or in Mr. Trotter's paper, viz., the effect of private or shop lighting on the streets. In some streets the public lamps were, to use a colloquialism, "nowhere." They were but useless and ludicrous little glimmers—difficult to discover amidst a blaze of shop and outside lighting. In the lists and tables of street illumination given by Mr. Trotter Cheapside was stated to have ten times the illumination of Regent Street, and twenty times that of others of their principal streets. He would like to know whether the light from private sources had been eliminated or included in the lists given, and if included, how were they to compare the public part of the lighting in the various streets. There were, of course, no shops in Park Lane or Ashley Gardens, but brilliantly lighted and many-windowed mansions and clubs must have some effect.

He particularly wanted to say that as long as shop-keepers were allowed to obtrude high-power lamps, so long will satisfactory street lighting be impossible. Street lighting was inseparably connected with shop-front lighting, and it ought to be made illegal for any shop-keeper to expose a visible light either outside his shop or in his shop window. (Laughter.) They knew very well that the City of London had introduced a regulation prohibiting high-power lamps outside the shops, unless screened in the direction of the road. He was sure we should come to it eventually, although it might seem absurd to practical engineers. Every one was prejudiced in regard to the things he was brought up in, and he (Mr. Darch) was certain that the future would be the shielded light. Going a step further, he thought that the ultimate solution of perfect street lighting would be the employment of diffused light obtained by illuminating the house fronts. Diffused light was enormously more useful than direct. Things appeared more natural and real. The present system of patchy, spotty lighting and impenetrable shadows destroyed identity and caused a great strain on the eyes.

Dr. L. Bloch (Berlin, *communicated*). —There are several comments that I would like to make on the proposed Specification for Street Lighting contained in Mr. Trotter's paper.

I consider the method of measuring illumination in a horizontal plane one metre above the ground as the best and most practical system, which has been recommended by the Verband Deutscher Elektrotechniker after exhaustive inquiries. This proposal is particularly welcome because it shows the beginning of international agreement on this point. Theoretically it might perhaps be still more correct to measure illumination on the pavement itself, but this presents considerable practical difficulties. As a matter of fact the comparison of different systems of lighting can be carried out in a safe

and trustworthy manner at a height of one metre, even when the height of suspension of the lamps compared differs considerably. Measurements of illumination on vertical surfaces are desirable as supplementary to measurements of horizontal illumination, but are not alone satisfactory. In my opinion a correct course has been followed in this draft specification in avoiding measurements in the vertical plane.

But I do not find myself in complete agreement with Mr. Trotter and the Committee on the question of minimum illumination. To my mind this does not conduce to the most correct conception of the value of street illumination. Probably only about 20 per cent of illuminated streets will be examined on the basis of minimum illumination; for in the side streets the value of the minimum illumination will be so low that its exact measurement with the customary types of photometers presents considerable difficulties. This involves a limitation of the proposed specification to quite a small section of street illumination. Moreover, it will often be found, even in quite strongly lighted streets, that values below the prescribed minimum will be found, because of the shadows cast by trees. One could, perhaps, prescribe that measurements will not be taken at such spots. But the very fact that such spots occur in otherwise very brightly illuminated streets, and that this is not exceptional, but quite common throughout the summer, shows that the prescription of a certain minimum illumination *alone* is not sufficient to ensure a well-lighted street.

The adoption of this prescription of minimum illumination would also exert a marked influence on the arrangement of a street lighting installation, and by no means a favourable influence. It would encourage the already prevalent, but injudicious method of placing lamps in the streets as high as possible; for it is common knowledge that by placing the lamps high one can in general get the best value of the minimum illumination, and the uniformity is also improved. But it is possible under these circumstances that there will be no single point in the street where the illumination is strong enough to read with ease.

If minimum illumination is to be the sole consideration, electric lighting would find itself in a particularly favourable position. By using 1,000 candle-power arc lamps or metal filament lamps at a height of about 10 metres it would be possible to obtain the same minimum value as with the same number of 3,000 candle-power high-pressure gas lamps at the usual height of 5–5½ metres; this appears very clearly from the investigations of street lighting undertaken and published by me. Moreover, if metal filament lamps were used the use of a reflector would appear scarcely necessary since these lamps naturally give out most light in a horizontal direction, which is favourable to a good minimum. Yet, as a matter of fact, the choice of a suitable reflector in conjunction with metal filament lamps is highly necessary in order to secure good street illumination.

That a good minimum illumination is not alone sufficient can also be seen from the most recent experiences in very uniformly and strongly illuminated streets. In spite of the particularly high minimum illumination these streets give the impression of being too dark—an impression that could only be explained by the fact that in consequence of the high uniformity attained, the bright spots in the neighbourhood of lamps were almost entirely missing. Electrical engineers certainly could comply readily with the limitation of minimum illumination. But it is preferable to find a method which could be complied with equally well by all systems of illumination.

To my mind the desired method could be based only on mean horizontal illumination; to determine mean illumination is certainly somewhat tedious, but its measurement and predetermination is still not so very difficult; and there are already various accurate and approximate processes to lighten the labour. Mean horizontal illumination is a true measure of the actual illumination distributed in the street. It applies equally well to

various systems of lighting and arrangements of lamps, such as we actually find in the streets at the present day. As a means of judging the uniformity of illumination in the street it should be sufficient to determine the maximum and minimum illumination or to specify the ratio between these two quantities. The recommendation of the Verband Deutscher Elektrotechniker, based on this system, have already been in operation for the last three years, and have given good results.

To put these remarks in a nutshell, I strongly advocate that the main horizontal illumination and not the minimum should be specified; or at least that, in addition to the minimum value, the mean and maximum horizontal illumination should also be stated. Only on this basis can a truly practical and useful specification, applicable to all methods of illumination, be prepared.

Dr. L. J. Terneden (Amsterdam, *communicated*).—I have studied Mr. Trotter's paper with great interest. The subject is an exceedingly important one, and such a specification seems a very good thing: here, in Holland, where the gas and electrical supply is almost invariably municipally owned, specifications for street lighting are seldom made.

The system of dividing streets into groups might well be extended for higher values, each addition of 0·1 foot-candles over and above E representing another class.

In stating the height at which measurements are to be made, would it not be well to use the exact equivalent of 1 metre, as done by Mr. Wilson (namely, 3·28 ft. [3 ft. 3⅜ in.]) ?

As regards the plane in which measurements are made, I think it is hardly sufficient to measure only in a horizontal plane, and would advocate that the minimum in a vertical plane perpendicular to the direction of the street traffic should also be determined.

Prof. H. Strache (Vienna, *communicated*).—The specification of street lighting is a subject of very great interest to illuminating engineers, and it would be very satisfactory if standardization in this respect could be agreed upon. Specially desirable is the consideration of illumination instead of the nominal candle-power, at present almost exclusively used in this country. It is hoped that, after methods have become standardized, they will rapidly find their way into practice.

Polar curves of light distribution are already frequently studied in judging the performances of a lamp; but still, as a rule, not in the very case where they are most essential, namely, in street lighting. Not only illuminating engineers, but also those less intimately connected with street lighting, should become familiar with the idea that a determination of horizontal candle-power alone is not sufficient.

As regards points of detail in the specification, I should like to refer to the replies of a Committee of the Verein der Gas und Wasserfachmänner, in Austria-Hungary, to the inquiries circulated by *The Illuminating Engineer* in 1911, with which I am in full agreement.*

Prof. S. A. Rumi (Genoa) writes expressing his approval of Mr. Trotter's suggestions. He adds that in Italy illumination contracts usually refer to the candle-power of the lamps rather than the illumination.

Mr. H. T. Wilkinson (Harrogate, *communicated*).—I regret I cannot be present at Mr. Trotter's paper, but enclose a few figures that may be of interest. At Barrow-in-Furness, in one of the streets 80 ft. wide, the minimum illumination is ·03, and the maximum ·35 foot-candle, giving a max./min. of under 12. In this case there are two 100-watt lamps, each in a suspension fitting hung from each tramway span, one on each side of the track, each lamp being 17 ft. 6 in. from the ground, and the spans are approximately 40 yds. apart. The consumption of electricity is, therefore, 8·8 kw. per mile.

* *Illum. Eng.*, Lond., vol. iv., 1911, p. 505.

Dr. L. Bell (Boston, U.S.A., *communicated*).—While fully realizing that the object of placing lights is, broadly, to secure illumination, I must confess myself opposed to making illumination the fundamental thing on which contracts are to be based and payments to be awarded. From the standpoint of experience here, there are two vital objections against illumination as the fundamental factor in street-lighting contracts. One of these bears upon both the contractor and the public, the other upon the public alone, but in a manner affecting its vital interests. In the first place, if illumination is to be the real basis of a contract, penalties under that contract must depend upon a measured deficit in illumination, and practically all photometrists in this country who have had experience with illumination measurements on the street recognize that the degree of obtainable precision is not sufficient to justify making them the basis of large monetary settlements. In a street-lighting contract involving £50,000 or £100,000 per year a difference of 2 or 3 or 5 per cent in the measured illumination is a very serious matter, and dependence upon measurements which are known to vary within at least this range would simply lead to exasperating litigation. I have made a very large number of measurements on the street, first and last, in a considerable variety of instances, and know from personal experience the magnitude of the difficulty here referred to, and the utter hopelessness of getting an amicable agreement between the municipality and the contractor on any such uncertain basis. There is no objection, if anybody fancies the idea, to putting in a minimum illumination clause, provided nothing of any importance is made to hinge upon it, in which case it might as well be forgotten. Second, the inevitable effect of a minimum illumination, which the contractor may furnish substantially according to his own plans, will be found to be the smallest total light flux which can be made to serve. A call for minimum illumination is practically a call for small gas or electric incandescents glimmering along the street at intervals as infrequent as can meet the specification for illumination midway between them. These are not matters of theory, but conditions which will inevitably confront the municipality in undertaking its street lighting. It is my judgment, therefore, that an illumination specification can only prove useful when it has very little to do with the real considerations of the contract. I have always looked upon a contract for street lighting as essentially a contract for service, under specified conditions, with certain specified illuminants, of which the performance can be both definitely ascertained in the laboratory and easily checked on the street. It is the task of the engineer having the work in charge for the municipality to see what luminous sources and what arrangement of them will give him the illumination required in streets of various classes, and then to insist on the use of these illuminants under certain standard conditions which can be maintained.

I think it wise to specify the kind of lamp, its standard conditions of operation (which shall not be departed from by more than a fixed limit), the time of lighting and extinguishment, and, if necessary, the character of the electrodes. In the case of one city to which I was adviser a few years ago, standard electrodes—of which the performance was ascertained in the laboratory—were laid aside, and electrodes for future use were required to be sampled and tested against these before acceptance. The result has been that the arcs, as worked in that particular city, have been held up to a candle-power more than 25 per cent in excess of that obtained with so-called standard electrodes of later manufacture specialized for life rather than light.

As regards the much-mooted question of whether illumination, when measured, should be measured on a horizontal plane or one approximating the vertical, I am inclined to favour the latter requirement, on the ground that about the last thing for which street illumination is used is the recognition of flat details on a horizontal surface. For

most purposes one has to depend on the illumination received from the lamps on one side only of the object under view, and in a direction somewhere nearly normal to the rays.

These comments are, of course, simply the result of experience in working under American conditions, and my British *confrères* may obviously find some of them less applicable to their own situation than I have found them on this side of the water.

I think that the suggestions for the draft of a standard contract are sufficient to secure good results, but I believe they would be much more easily carried out if more stress were laid upon the candle-power at a fixed angle from the lighting units to be furnished, when burned under easily defined standard conditions of operation.

Mr. L. B. Marks (New York, *communicated*).—I have given the paper only casual study, and shall not attempt at this time to discuss several mooted points which are raised therein.

The paper shows a great amount of work on the part of the various Committees who had to do with the subject, and lays before us in concrete form a number of suggestions that may lead to a closer agreement as to the standard clauses for inclusion in a specification of street lighting.

In view of the broad scope of the general subject of illumination, we can hardly expect uniformity of opinion on the main points, to say nothing of the details of a specification of this character. Even in specifications for electrical work, which have been more or less standardized for many years past, the so-called standard clauses of the specifications are sometimes of secondary importance, the real meat of the specifications being in those sections which are specially prepared to meet specific conditions. In the matter of illumination the more or less rapid changes in the art make it comparatively difficult to bring about standardization.

Any attempt to arrive at a proper basis for illumination specifications, whether for street lighting or for interior lighting, should be welcomed and encouraged, especially if care be taken to preserve the proper sense of perspective in the formulation of the specifications.

In considering specifications for street lighting the intrinsic brightness of the lamp may be an important and even a vital question. In the present paper reference is made on p. 242 to a preliminary memorandum prepared by Mr. Frank Bailey, describing the ordinary rule of thumb practice for street lighting, calling attention to "the advantage of specifying that which has really to be paid for, namely, the actual light given where it is required, or, in other words, illumination." I would go one step further, and state, perhaps, the *hygienic* or the *proper* illumination. This brings a physiological factor into the case. If the illumination does not enable us to see things well, then, irrespective of whether or not the specification is met as to intensity of illumination, we are really not getting what we paid for. In other words, in a practical specification for lighting one cannot divorce the "actual light given where it is required," or the "illumination," from the lighting source. Cause and effect must be considered jointly.

On p. 243 of the paper the statement is made that "the lamps must, of course, be so arranged that they are free from glare." Therein lies the rub. A lamp might conform to the requirements of all the clauses in the proposed specification, and in competition outdistance all competitors by furnishing the highest minimum illumination; whereas, if judged from the broad standpoint of good lighting, this very lamp might be rejected as the poorest of the group tested, because its intrinsic brightness is so great at certain angles as to interfere with good vision on the street. Yet the specifications say nothing about intrinsic brightness, which, while sometimes of secondary importance, depending upon the height of the lamp, total flux of light, &c., may nevertheless be, and often is, a matter of prime and determining importance.

In a recent preliminary test of street lighting in the city of New York, half of the street was lighted by lamps equipped with diffusing globes, and the

other half by lamps equipped with clear globes. Though the minimum illumination on that section of the street having lamps equipped with clear globes was much greater than that on the other half of the street, the decision was unanimously in favour of the lamps equipped with diffusing globes, because of the comparatively low intrinsic brightness of the latter and consequent freedom from glare.

Dr. C. H. Sharp (New York, U.S.A., *communicated*). — Mr. Trotter's argument that the illumination furnished, rather than the candle-power of the lamps, determines the quality of street lighting is apparently incontrovertible. Whether the illumination, rather than the type and candle-power of lamps, should appear in a street specification is evidently something where differences of opinion may occur. These differences may depend somewhat upon the conception which the lighting company has of the character of the service which it is rendering—that is, whether it is furnishing an illuminant or furnishing illumination. The thing which the public is interested in is the illumination, but a very good street-lighting specification can undoubtedly be drawn on the basis of the illuminant. This shifts the responsibility for illumination results from the lighting contractor to the city engineer. Accepting the illumination as the basis for lighting contracts, it remains to consider the specification of minimum illumination as proposed by the Committee.

Where the street is to be everywhere brightly illuminated the specification of adequate minimum illumination should be sufficient to ensure good illumination, although it may not lead to correct results in comparing different systems.

Where, however, illuminants are sparingly used, as is the case in the great majority of streets, the specification of the minimum illumination, or especially of the candle-power at 10 degs. below the horizontal, furnishes no sufficient criterion for the quality of the illumination. The brightness of the street surface depends, other things being equal, on the amount of luminous flux delivered to that surface. If a sufficient flux is delivered, and this flux is properly distributed, the requirements are reasonably well met. The flux delivered is measured by the average illumination over the area; the proper distribution may be fairly well insured by specifying the minimum illumination. With relatively dim lighting it is important to have some fairly bright areas, as Millar has pointed out, and it may be desirable to obtain such brightness even at the expense of the minimum illumination. A street having a uniform illumination of 0·01 foot-candle would be a very dimly lighted street. One having a minimum of 0·01 foot-candle, and an average illumination of 0·03 foot-candle, would be unquestionably much better lighted. Under the proposed specification these two conditions would be put on a parity, which is manifestly illogical and unjust.

These facts have evidently been considered, but the specification of average illumination has been rejected apparently because of certain real or imagined difficulties of experimental determination. Mr. Trotter says it would amount to a photometric survey of the street. This would seem to give a rather exaggerated idea of the difficulties. Such a survey might well be required to determine whether the type of illuminant gives the required flux, but for periodic checks of the illumination a simpler procedure might answer. For instance, a factor might be agreed upon as a result of tests, showing the average ratios of the average illumination to the minimum illumination, and thereafter the minimum alone would need to be measured. Instead of making a survey of the street, the flux of light method, which deserves different consideration from that which Mr. Trotter accords it, might be used. It is really no more difficult to compute the total flux of a lamp than it is to compute the mean spherical candle-power.

The flux emitted in any zone of a lamp is very readily determined from its candle-power distribution curve. In fact, it is the practice of the Elec-

trical Testing Laboratories, in sending out distribution tests, to give the lumens emitted in each of the 10-deg. zones of a lamp. Dividing the area of a circle having the distance between lamps as its diameter by the flux falling on that circle from a lamp placed at the given mounting height gives at once the average illumination over the area. The flux of light method of computing average illumination is being used very generally, and is found to make a very great saving as compared with the older methods of accomplishing the same purpose. Mr. Trotter's expression that he who does this "goes out at the same door wherein he went" is not what those who are experienced in the use of this method have found out.

Therefore, the introduction of the average illumination in the specification does not involve excessive difficulties in the matter of measurements. The lighting of streets is a matter of sufficient importance to justify a considerable amount of care and effort in following it up. Justice and the attainment of proper results should not be sacrificed to an expediency which concerns only the minor matter of measurements.

Similarly, it would appear that inasmuch as the quantity under consideration is the illumination on the street surface, it is this illumination which should be measured, and not the illumination on a plane selected with a view to the photometrist's convenience. If the proposed height of one meter for the measuring plane were to be reduced to zero or to 10 cm. there would be a gain in logic at least.

The Committee has done a most excellent piece of work, which has the merit, not always present, of being based to some extent on actual observations and measurements taken in the street.

Mr. Preston S. Millar (New York, U.S.A., *communicated*).—Perhaps the most interesting and impressive single feature of the record in Mr. Trotter's paper is the happily conceived plan of co-operation among the four Societies who, through the Joint Committee, have sought to arrive at a generally acceptable specification for street lighting. This plan appears so meritorious that it is to be hoped that it may be emulated in other countries.

The members of the Committee are to be congratulated upon their evident careful consideration of the many phases of this intricate problem which Mr. Trotter discusses so clearly in his paper. It is made clear that extensive deliberation has preceded the action of the Committee in recommending as a basis of rating :—

(*a*) Illumination rather than candle-power.

(*b*) Horizontal intensity rather than intensity upon a surface otherwise inclined.

(*c*) The minimum intensity rather than the average or some relation between these and the maximum intensity.

(*d*) A height of 3 ft. 3 in. rather than the street level for measurements.

Each of these four elements of the problem might be discussed *pro* and *con*. I shall confine my expression, however, to adverse comment upon the choice of a minimum intensity as a basis of rating for a street-lighting system. For conditions in America, at least, this provision appears to the writer to be unsatisfactory.

To base the valuation of the illuminating effect upon the minimum intensity is to invite manipulation of light with a view to producing a relatively high minimum. In some street illumination it is probably important to increase the minimum at the expense of intensity elsewhere, and the specification may be effective in promoting this. But in neglecting all other intensities the way is opened for abuse and unwholesome development.

In America there was proposed in 1907 a basis of rating which was somewhat analogous to that under consideration. Fortunately, it has not received much support, and has not entered into commercial practice to any considerable extent. Lamps were to be rated in terms of normal illumination intensity measured at a distance of 200 ft. to 300 ft. from the lamp, which corre-

sponded usually with an angle of about 10 degs. below the lamp horizontal. Practically, as in the specifications now proposed, this resolved itself into a uni-directional rating for illuminants. To illustrate how unsatisfactory a rating of this kind may be, I would cite data from a paper by Sharp,* who described a reflector designed to direct along the street all light from the upper hemisphere, and much of the side-light, thereby reinforcing greatly the minimum intensity. Sharp, in emphasizing the valuable light-reflecting qualities of his reflector, showed that, according to the method of rating just described, a 50 c.-p. lamp equipped with his reflector should be rated something like 25 per cent higher than a 4-amp. Magnetite arc lamp giving six or seven times as much light distributed largely below the horizontal. He did not, of course, mean to imply that the 50 c.-p. lamp so equipped is really equivalent to the Magnetite lamp.

There can be no question but that for street lighting purposes the Magnetite lamp was much the superior; yet, if the uni-directional rating had been adopted, it would have been shown much inferior to the 50 c.-p. incandescent lamp with the Equilux reflector.

The history of illumination is replete with instances of the unwisdom of uni-directional lamp ratings. The writer submits that in this period of advance in the science and art of illumination it would be an unfortunate retrogression to adopt any basis which so closely approaches a uni-directional rating as does that contemplated by the Joint Committee.

But there is a further serious objection to the criterion afforded by the minimum intensity. Large objects are seen on the street at night, not so much by reason of the light which falls upon them, or which is reflected from them, as because they are contrasted against some background of markedly different brightness.* Usually this is a contrast of a dark object against a light street surface. This silhouette effect is greatly enhanced by local bright areas on the street near distant lamps. Thus a nearby vehicle or pedestrian may be discerned most readily because silhouetted against a light street surface which may be one-quarter of a mile distant. This mode of discernment is very largely dependent upon the *maximum* illumination intensity. According to the method of rating which is recommended by the Committee, two street-lighting systems are of equal value which yield the same minimum illumination intensities, even though one has a maximum ten times the minimum, and the other has a maximum twice the minimum. In practice, I venture the assertion that, other things being equal, the street-lighting system in which the higher maximum illumination prevails is usually superior, even though the uniformity be of a lower order.

The writer, therefore, desires to be recorded as not in favour of minimum illumination intensity as a criterion by which to evaluate street lighting service, because, first, it is practically a uni-directional rating for the lamps, and all uni-directional ratings are incapable of affording a reliable and generally applicable measure of illuminating value; and because, secondly, he believes that the minimum intensity is by no means a criterion of the value of the illumination, this being dependent as well upon the maximum and, perhaps, the average intensity.

* C. H. Sharp, 'A High Efficiency Reflector for Street Lighting,' *Transactions* of Illuminating Engineering Society, vol. v. (1910), p. 375.

* P. S. Millar, 'Some Neglected Considerations Pertaining to Street Illumination,' *Transactions* of Illuminating Engineering Society, vol. v. (1910), p. 653.

ERRATA.

On p. 259, second column, line 22, for "very great illumination" read "very striking agreement."

[*The continuation of this discussion at the meeting on April 29th, and Mr. Trotter's reply, will be published in our next number.—Ed.*]

The Economic and Hygienic Value of Good Illumination.*

ABSTRACT.

[A close connection may be traced between the development of artificial light and social progress. Light plays an important part in our streets, on the railways, in shops, schools, factories, and places of entertainment. Good illumination is essential (a) as a hygienic necessity (b) as a means of preventing accidents (c) on purely economic grounds. Defective lighting in the home or in the school is prejudicial to the health of children ; in factories poor illumination leads to accidents, ill-health, spoiled work, and diminished output. The question is raised "what is meant by adequate illumination? Exhaustive tests and further data are needed to specify this more exactly, although there is already agreement on some fundamental points. Finally the author gives a summary of the important events of the last few years leading to the appointment of the Committee on Illumination by the Home Secretary.]

An interesting meeting of the Royal Society of Arts, which may one day be of historic interest, was held in London on Wednesday, February 5th, when Mr. Leon Gaster read a paper emphasizing the importance of good industrial illumination. Quite a number of members of the Illuminating Engineering Society were present, and the chair was taken by Sir Arthur Whitelegge (H.M. Chief Inspector of Factories).

Mr. Gaster made a few preliminary remarks acknowledging the sympathetic attitude of the Royal Society of Arts towards matters of illumination and their constant kindness to the Illuminating Engineering Society. From its earliest commencement the Royal Society of Arts had been closely identified with social progress, and illumination, being one of the most civilizing influences of the century, justly received their attention.

Illumination and Social Progress.

A striking parallel may be drawn between intellectual and moral progress and the developments in the art of using artificial light. In the dark ages superstition and prejudice were doubtless fostered by the fear of the night time, and even to-day the conception of darkness as illustrating error and confusion occurs in many familiar phrases. The lighting of London alone would form an interesting study. The improved illumination of its streets has been one of the most potent agents in making them safe and in suppressing disorder.

The ease with which people travel to various parts of London is largely the result of better lighting, and the modern social instinct is doubtless also connected with facility in producing light. Business and pleasure are now pursued in the evening with far greater zest than in the past, when no one stirred outside his door after darkness had fallen. On our railways lighting plays a conspicuous part both in making it possible to read on a journey, and in the form of illuminated signs enabling people to see at a glance when and where the next train departs.

Light also plays an important part in the concert hall, the restaurant, and on the stage. In theatrical performances as in education the tendency is to appeal to an increasing extent to the eye rather than to the ear. It is therefore most essential that the artificial light so widely used at the present time should also be employed judiciously. One must bear in mind the object to be served by installing each light, and make sure that it is installed in such a way as to aid the user.

Mr. Gaster added that good lighting was essential (*a*) as a hygienic necessity, (*b*) as a means of preventing accidents, and (*c*) on purely economic grounds. Take, for example, the home. An ill-lighted house is also an ill-kept one. Insufficient illumination naturally favours the accumulation of dirt in corners, and impedes work in the kitchen. For the sake of the children

* Abstract of paper read by Mr. L. Gaster before the Royal Society of Arts, London, on February 5th, 1913.

good lighting was particularly essential. At present efforts are being made to ensure that the lighting of school-rooms in this country shall be kept up to a good standard. But this is not enough. The precautions of school authorities may be nullified if the child is allowed to ruin its eyes at home.

School Lighting.

Statistics are available to show that a steady deterioration in eyesight takes place during school life. There seems reason to suppose that the nature of some kinds of work, namely, reading fine type, fine sewing and stitching, &c., is unsuitable for young eyes, and has been partly responsible for defects of vision. Efforts are now being made to give young children more suitable work to do.

The British Association has recently issued a report containing actual examples of the print which may be safely read by children of various ages, and Dr. Hope of Liverpool has traced very clearly the prejudicial effect of much sewing in the case of girls in the elementary schools. He recommends that no sewing should be done by girls under the age of seven. It is also realized that poor lighting is one of the most common causes of eye-strain and brain-strain. Dr. Kerr, medical officer of the London County Council, drew attention to this fact in his evidence before the Committee on Physical Degeneration some years ago. It is impossible for a young child to work in comfort if he has difficulty in making out the letters, or if his eyes are being constantly troubled by the glare from badly placed sources of light.

Natural illumination in school-rooms also requires to be studied, the more so because daylight is not under our control to the same extent as artificial illumination, and varies so greatly at different periods of the year. When a school has once been built it is not always easy to remedy defects in the size and position of windows. One would like to make sure that the next generation of children do not suffer from the lighting defects that have characterized schools in the past.

Poor illumination is also responsible for defective vision in adults, particularly in certain trades, such as spinning and textile work, printing works, &c., where a special tax is often made on the eyes.

There are also possibilities of permanent injury to the eyes owing to an exposure to an excessively brilliant light. For example, it is well known that precautions must be taken by men in welding operations, using the electric arc or oxy-acetylene flame, in order to avoid the effect on the eyes of the ultra-violet light commonly generated in this process. A somewhat similar case is to be found in the cataract of the eye which is prevalent among glass-workers; by some this has been ascribed to the effect of ultra-violet rays.

Another example of a disease of the eye, apparently due to deficiency of light, is the "nystagmus" met with in some British coal mines. This is now believed by some authorities to be due mainly to the weak illumination in which such work is carried out.

Bad Lighting as a Cause of Accidents.

Turning next to the value of good illumination as a means of preventing accidents, Mr. Gaster made special reference to the report of a Departmental Committee on Accidents in Factories issued in 1911, and mentioned instances of accidents occurring to men carrying molten metal and stumbling along ill-lighted passages, or working on scaffolding by the faint light of early morning. It was suggested that the increase in the number of accidents in the streets during recent years was partly due to the multiplication of very bright street lamps, which were apt to dazzle drivers and people walking. The actual illumination in the streets was much higher than it used to be, but some method of toning down the brilliancy of modern lamps seemed imperative.

As an illustration of the connexion between light and the prevalence of accidents Mr. Gaster reproduced some statistics presented by the Fidelity and Casualty Company of New York.

These showed conclusively that most accidents occurred in the short days of winter when artificial light was mainly needed.

But besides being necessary to health and safety good illumination is desirable on economic grounds. A breakdown in the machinery, or an accident to a member of the staff, always means loss; even after the accident the effect is felt for some time, and leads to disorganization of work.

There are many instances in which a stoppage of the machinery, even for a short time, throws the whole system out of gear, and poor lighting increases the difficulty of locating the defect.

Good Lighting Pays the Employer.

On broad grounds every one will admit the folly of paying a highly trained staff and installing expensive machinery, and then neglecting to provide sufficient light. The inconvenience of insufficient illumination is thoroughly realized by employers. Mr. Gaster mentioned that it had been a frequent experience of his to find that when the light in one section of the factory was brought up to the requisite standpoint a clamour immediately arose on the part of the work-people in other sections lighted on the old plan. Sometimes girls who were piece workers urged that it was unfair that some of them should be treated better than others in this respect. There was a general recognition that good lighting was an advantage both to the employer and employees. It meant that less work was rejected; the output was increased, and both parties were able to earn more.

It is probable that the cost of lighting is, in general, but a small fraction of the total wages bill—in many cases less than 1 per cent. Therefore, an improvement in the illumination would often cost very little in comparison to the enhanced efficiency with which work was carried out. But in many cases it was possible to get improved illumination and yet accomplish a saving, merely by seeing that the light was put to a better purpose.

Bad Lighting and Spoilt Work.

It is interesting to note that the census experts gave 1 per cent as the gross spoilage of American manufacturers during the year 1909, which amounts approximately to 150 million dollars. "Of this vast amount 75 per cent is said to have occurred under artificial light, and experts seem to agree that 25 per cent of this number could have been avoided by good illumination."

The question arises, what is meant by adequate illumination. On this point we have much to learn, but there are some simple recommendations that will meet with general approval, and have been concisely stated in the pamphlet entitled 'Light and Illumination: their Use and Misuse,' reprinted from *The Illuminating Engineer*. Special importance should be attached to the use of proper shades and reflectors, both with a view to avoiding glare and directing the light where it is chiefly needed.

Another important development of the last few years has been the invention of convenient methods of measuring illumination. More than 2,500 such measurements in over 125 factories were recently made by Mr. D. R. Wilson in the course of his investigations on behalf of the Home Office. Photometric data of this kind form a most valuable record.

At present one meets with an extraordinary variation in the amount of light used even in the same trade and for identical purposes. What is needed is to collect data establishing approximately what illumination is required in each case.

Important Events of the Last Three Years.

The concluding portion of the paper was devoted to a summary of important events of the past few years. Mr. Gaster paid a tribute to the valuable work carried out by the Factory Department of this country under Sir Arthur Whitelegge, and in particular to the series of measurements undertaken by Mr. D. R. Wilson. The desirability of establishing some standard of illumination in factories was now being

considered, and it was of interest to notice that the latest Indian Factory Act for 1911 already requires good lighting in general terms.

Valuable opportunities of bringing home the need for good lighting were afforded at the International Congress on Industrial Hygiene held in Brussels in 1910 and at the First International Congress for the Prevention of Industrial Accidents held in Milan in 1912. The author had contributed papers at both these meetings, and quite a number of communications dealing with various aspects of lighting were received. It was at Brussels that the question of miners' nystagmus and its connexion with poor illumination was first brought forward. In Milan the importance of lighting matters to insurance companies was emphasized, and it was suggested that specially favourable terms should be given to firms whose premises were well lighted; also that some more complete method of classifying accidents and ascertaining what proportion was due to poor lighting should be undertaken. Last year an important step had been taken by the French Government in appointing a special committee to study the hygienic effects of illumination, and it was hoped that similar committees would be formed in other countries. The New York Factory Commission was now considering the formation of a bill requiring good illumination in factories in general terms, and it was anticipated that this would come into force in October, 1914. This step was largely due to the influence of the American Illuminating Engineering Society. A similar society had just been formed in Germany, and it was hoped that it would be beneficial in bringing forward the claims of good illumination in that country.

In conclusion, Mr. Gaster remarked that the campaign for better lighting in Great Britain had culminated in the appointment by the Home Secretary of a committee charged with the investigation of industrial illumination, of which the Chairman and himself were both members. Enough had been said to show the important field of work of the committee. He hoped that it would be possible to arrange for co-operation with similar committees in other countries so as to avoid overlapping, and that in future their joint results might be put forward at an international congress with a view to framing recommendations applicable to lighting throughout the world. This country was well fitted to act as a link between the Continent and the United States, and to take the initiative in calling this congress.

The Chairman (Sir Arthur Whitelegge, K.C.B.) in opening the discussion, remarked that it would be evident to all who had listened to the paper that an overwhelming case had been made out for adequate lighting; but this required more precise definition. He appreciated the reference to the work of his own Department and that of Mr. Wilson. He hoped that eventually Mr. Gaster's idea of an international congress would be realized.

The Committee on Illumination had before it a heavy task, but it would be their aim to draw up their conclusions in a convenient form available for the guidance of all concerned, both employers and workers.

Subsequently, Mr. F. W. Goodenough and Mr. Frank Bailey expressed their appreciation of the paper, and their conviction that manufacturers and employers of labour, as well as private individuals, would welcome suggestions for improving their lighting. Mr. Bailey referred specially to the necessity for proper methods of shading, and alluded to the change carried out in the hall when the meeting was held.

(Previous to this meeting some changes in the customary lighting of the hall had been made. Lamps of higher candle-power had been introduced, and the four chandeliers had been equipped with different types of globes and reflectors, namely, two varieties of veluria glassware, Holophane concentrating reflectors and Holophane globes. Three simple forms of illumination photometers, the Holophane lumeter, the lightometer, and the luxometer, were also exhibited during the evening, and measurements were

carried out in order to show the increase in illumination secured. It was reported that the general illumination on the lecture table was now over 3 foot-candles, whereas it was formerly less than 1 foot-candle.)

Sir Henry Trueman Wood (Secretary of the Royal Society of Arts) referred to the history (extending over 140 years) of the lighting of the room.

It was originally lighted by three or four oil lamps, and a lamplighter was employed, who was paid 4½*d.* per lamp per meeting for cleaning and filling the lamps. This method continued for nearly eighty years, but towards the end of the century various experiments, including the installation of a Bude lamp in the centre of the room, were tried. The first introduction of gas occurred in 1815, when a lamp was put up outside the street entrance. But at this time, the purification being still incomplete, gas illumination could not be introduced into houses. It was not until 1845 that gas lights were substituted for the oil lamps at the four corners of the hall. In 1882 electric light was introduced. He believed this to be the first public building in London lighted by electric light. But it was not until 1899 that current was taken from the street mains, the arrangement before this time being to obtain electricity from a plant on the premises consisting of an Otto gas engine, a Siemens dynamo, and an E.P.S. storage battery.

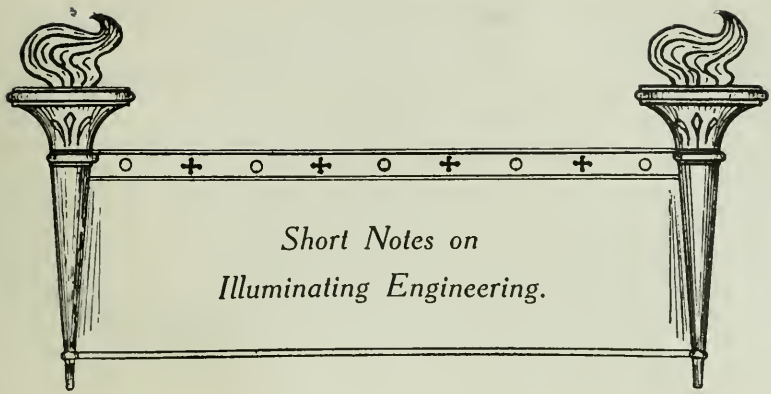
Among others who spoke, Mr. D. R. Wilson remarked on the anomaly that while the factory acts provided against other risks to which workers were exposed, they left unconsidered that most important organ—the eye. He hoped that legislative provisions on this point would be made as a result of the committee's labours.

Mr. C. C. Paterson complimented Mr. Gaster on his paper, and emphasized the big programme before the committee and the necessity for exhaustive tests. Mr. F. W. Willcox quoted some instances of the pervasive character of illumination, affecting as it did every walk of life and phase of science and industry. Dr. W. J. M. Ettles referred to the importance of the colour of the light as affecting acuteness of vision and the desirability of avoiding excessive contrasts.

Mr. T. E. Ritchie emphasized the fact that good illumination invariably paid the employer, and it was often possible to show a tangible saving in labour following the increase in light provided. It was, however, usually difficult to obtain permission from manufacturers to present data of this kind. The speaker then threw upon the screen some illustrations of installations regarding which he had obtained definite data. In one case, by doubling the illumination, the output of a factory had been increased 11 per cent.

Mr. R. J. Wallis-Jones briefly commented on the vagueness of the phrase "adequate lighting," and Miss A. Anderson raised the interesting question how it was that the ancients had been able to execute such fine work in the tombs and catacombs to which, apparently, daylight had no access. The fine colouring of the pictures seemed to suggest that much more efficient sources of artificial light might have been available than was generally believed.

The hour being somewhat late, Mr. Gaster replied very briefly to the discussion, expressing thanks for the kind references to his paper, and commenting briefly on the remarks of the various speakers, with which he found himself in general agreement. He had been particularly interested in Sir Henry Trueman Wood's account of the lighting of the hall of the Royal Society of Arts, which had always shown its enterprise by investigating each new form of illumination as it was invented.



PUBLIC LIGHTING IN FRANCE.

According to a recent number of *The Electricien*, there are in France ten thousand towns having more than one thousand inhabitants where some form of distributed public lighting ought to be installed.

However, there are at present only 4,094 such towns, illuminated as follows :—

Electricity	2,673 towns
Gas Lighting	1,249 ,,
Acetylene	172 ,,

There are, therefore, more than 6,000 towns and villages at present unlighted. It would appear that electricity has special advantages in districts such as those in the Pyrenees where water power is available. Gas works can hardly be economically installed in towns of less than 5,000 to 6,000 inhabitants; acetylene is particularly serviceable in sparsely populated districts.

INDUSTRIAL HYGIENE IN NEW YORK.

We note that a lecture on the above subject is to be delivered by Mr. L. B. Marks, forming one of a special course given by the Medical Society of New York, under the joint auspices of the American Medical Association and the New York Academy of Medicine.

THE EDUCATION OF THE BLIND.

At a meeting of the Royal Society of Arts, on February 26th, a most instructive paper on this subject was read by Mr. H. J. Wilson (Secretary of Gardner's Trust of the Blind).

To many of those present it was a revelation to discover how much can be done for the blind in these present days, and to what perfection their education has been brought.

Special instructions are also issued to parents of children, *e.g.* :—

" Never allow your children to use their eyes in the twilight or by insufficient light, or they will become weak and short-sighted."

LIGHTING AND OUTPUT.

In a recent paper before the American Institution of Electrical Engineers Mr. Esheleman remarks that when winding coils for electric machinery he found he could only earn $1·10 on the night shift, while on the day shift he earned quite $2. Moreover, while only 5 per cent of the coils wound in the day time failed to pass the insulation test, as many as 10–15 per cent of those done at night were rejected.

This is quoted as an example of the disastrous effect of imperfect artificial illumination on the speed and quality of work.

(Photo taken entirely by artificial light.)

TWO INDIFFERENT EXAMPLES OF SHOP-LIGHTING.

THESE two examples of shop window lighting illustrate the primitive system, still very common, of exposing bright lights to the eyes of passers-by.

The arc lamps on the right are hung at a low level. Doubtless they serve as an advertisement, but they are apt to dazzle the eyes of passers-by; it would be better to use a diffusing screen—for example, having the name of the shop engraved on it in coloured letters—on the side facing the street. The brilliancy of the lights would then be toned down, and the full effect obtained from the strong illumination of the pavement and the goods in the window.

The lighting of the window on the left has little to recommend it. Bare metallic filament lamps are distributed among the goods, where they interfere with the comfort of any one looking into the window. It is preferable to light such a window, like the stage at the theatre, by concealed lamps. *Light on the object, not in the eye*, should be the motto.

LIGHT IN MYTHOLOGY AND RELIGION.

A RECENT number of the Edison monthly contained the first of a series of articles tracing the association of light with religious ideas. In the oldest parts of the sacred writings of the ancient Persians, the seeker after truth thus addresses the Supreme Being:—

"That I shall ask Thee, tell it me right, O Ahura! Who is holding the earth and the skies above it? Who made the waters and the trees of the field? Who is in the streams that they so quickly run? Who is the creator of the good-minded Beings, O Mazda?"

The answer of the Persian is, like that of most primitive peoples, It is the Light, Light the Glorious, Light the Beneficient, Light the Giver of all Good Things.

As is well known the prophets and teachers of Israel constantly employed light and darkness to portray the contrast between good and evil. Many of the old rints representing such incidents as the conflict of St. George and the Dragon employed the same idea, the sun being shown bursting through a sky to illustrate the victory over darkness and evil.

Review of the Technical Press.

ILLUMINATION AND PHOTOMETRY.

The chief matter commented upon in the British press has been the paper by Mr. Trotter containing the draft specification on street lighting, which appears elsewhere in this number.

The subject of photometry is represented by an interesting communication by MM. Broca, Jouast, and Laporte (*Bull. Soc. Int. des Électriciens*, Feb.). The authors describe some **Photometric Tests on the Neon Tube,** leading to surprising results. Under different conditions personal errors of as much as 100 per cent occur; this is ascribed partly to individual peculiarities and partly to the Purkinje effect. Other experiments deal with the influence of this light on acuteness of vision, and on the opening of the pupil aperture. Some experiments on the quartz tube mercury vapour lamp are also described. It seems that pupil contraction may be caused by ultra-violet rays, and that the presence of these rays also leads to a more sustained "after-image." For ordinary purposes of illumination the lamp should also be equipped with the outer globe, which absorbs the ultra-violet radiation.

The question of **Colour Photometry** is also taken up in an article by M. Luckiesh (*Elec. Review* and *Western Elec.*, March 22nd). The chief point in the article is his observation that the Purkinje effect, characteristic of the equality of brightness photometer at low illuminations, is actually reversed in the case of the flicker instrument.

In the American press there have been a number of articles describing special installations, including some utilizing the semi-indirect and cornice lighting. A novelty is the **Curtis Portable Lamp,** which is so designed as to illuminate the table and also to throw a strong light upwards on to the ceiling (*Elec. Rev.*, &c., March 1st).

Licht und Lampe contains a number of illustrations of ingenious new types of decorative fixtures and artistic indoor lighting.

In *The Edison Monthly* there is a serial article entitled 'The Light Invisible,' in which the part played by light in connexion with religion, and as an influence on the minds of primitive peoples, is traced in a popular way.

ELECTRIC LIGHTING.

There have not been many developments to record in this section. The chief item is the recent paper by S. L. Pearce and H. A. Ratcliff read before the Institution of Electrical Engineers dealing with **Recent Developments in Manchester Street Lighting.** Two streets lighted respectively by gas and electricity are compared, and full figures for the illumination and cost are given. An interesting point in the paper is the authors' account of their attempt to soften the light of flame arc lamps without interfering with the distribution of light in desired directions. One plan adopted was to cover the lamps with a graded obscuring material so as to produce the most pronounced shading effect in the case of the rays striking the lower part of the globe.

C. F. Lorenz (*Elec. World*, March 8th) describes a curious effect of **Electrical Discharge on the Acetylene Flame.** It appears that a discharge of this kind stiffens the flame and makes it more luminous, and that a distinct connexion between the increased brightness and the current consumed can be traced.

GAS, OIL, AND ACETYLENE LIGHTING.

The Manchester street lighting has been much discussed, and there is a variety of articles dealing with high-pressure gas lighting. The new "Silica" caps for use with the Keith high-pressure lamp are illustrated in an article in the *Journal of Gas Lighting* (Feb. 25th), and it will be interesting to see how widely this novelty is adopted in practice. The use of high-pressure lamps for advertising purposes has also received attention. There seems room for forms of reflectors to direct the rays on the sign illuminated; in some of the illustrations shown the lamps are perhaps a more prominent feature than the object they are intended to illuminate.

Reference may also be made to some ingenious devices for producing **Flashing Signs Lighted by Gas,** a field that has hardly been exploited much as yet (*Jour. Gas Lighting*, April 8th).

A paper by FRANKLIN THORP (*J.G.L.*, April 8th) contains some interesting scientific observations on the **Mixing of Gas and Air** for lighting and heating. This appears to have distinct theoretical advantages. A table is given showing the intimate connexion between flame temperature and intrinsic brilliancy.

There is some speculation as to the lighting arrangements to be made at the **National Gas Exhibition** to take place this autumn. Illumination is to form a prominent feature, and some sketches of suggested schemes of lighting have already been presented. From these it appears that special fixtures are to be a prominent feature.

The American press, as usual, contains a number of articles describing gas lighting installations, including the lighting of a bowling alley (*Am. G.L.J.*, March 10th). W. WEBB describes the use of special "amber" mantles from which a gain in illumination of 20 per cent is said to have been obtained, and also a very pleasing effect (*Am. G.L.J.*, March 10th).

In the German magazines there is a series of articles by ALBRECHT comparing the relative advantages of gas and electricity for street lighting. R. SCHALLER (*J.f.G.*, April 5th) discusses the manufacture of chimneys out of Jena glass. He says that the obscuring effect on the glass, leading to gradual disintegration and cracking, is often due to the presence of slight sulphur impurities which combine with the glass surface; but with the latest varieties of Jena glass this disintegration is much less pronounced

---

List of References:—

ILLUMINATION AND PHOTOMETRY.

Americo, A. Fondamenti e Progressi nella technica dell' illuminazione (*Atti della Assoc. Elettr Italiana*, March 15th, 1913).

Broca, Jouast, and Laporte. Études des nouvelles lampes électriques luminescentes—Quelques Difficultés de la photometrie des sources incandescentes industrielles (*Bull. Soc. Int. des Electriciens*, Feb.).

Crouch, L. Relative advantages of Direct, Semi-Indirect, and Indirect Lighting (*Elec. Review*, March 21).

Editorial. Heterochromatic Photometry (*Elec. World, N.Y.*, March 22).
Heterochromatic Photometry (*Elec. World, N.Y.*, April 5).
The Commercial Basis of Public Street Lighting Contracts (*G. W.*, April 19).

Luckiesb, M. Light and Art (*Elec. Rev. and West. Electrician*, March 22).
The Purkinje Effect with Equality of Brightness and Flicker Photometers (*Elec. World*, March 22).

Niemann, W. Die Anfänge der Strassenbeleuchtung (*Licht und Lampe*, Feb. 22).

Norden, K. Lichtstrom und Lichtintensität von Leuchtlinien (*E.T.Z.*, March 13).

Semenza, G. L' arte d' illuminare nei suoi rapporti col diffondersi dell' illuminazione elettrica (*Atti della Associazione elettrotecnica Italiana*, Jan. 15).

Voege, W. Die Strahlung unser kunstlichen Lichtquellen im Vergleich zu einander und zum Tageslicht (*Licht u. Lampe*, March 27).
The Wiring of an Interesting Installation for Indirect Lighting (*Elec. Rev., N.Y.* March 29).
The Light Invisible (*Edison Monthly*, Feb., March, 1913).
The Lighting of Factories and Workshops (*Am. Gaslight Jour.*, March 10).
First Meeting of the German Illuminating Engineering Society (*J.f.G.*, March 22).
The Curtis Portable Lamp (*Elec. Rev., N.Y.*, March 1).
Deutsche Beleuchtungstechnische Gesellschaft (*E.T.Z.*, March 27).
Postal Car Illumination Tests (*Elec. World*, March 29).
Industrial Illumination and Safety (*Elec. World*, April 5).
Die heutige Beleuchtungsindustrie (*Licht u. Lampe*, Feb. 27).
Die Beleuchtungsindustrie und die Frühjahrs-Messe, 1913 (*Licht u. Lampe*, March 27)
Kunstlerische Innenbeleuchtung (*Licht u. Lampe*, Jan. 20).

ELECTRIC LIGHTING.

Armagnat, H. Dynamos pour l'éclairage des automobiles (*Rev. Electrique*, Feb. 7).

Darmois, E. Nouvelle Lampe à mercure pour reseaux alternatifs (*Rev. Electrique*, Feb. 7).

Lorenz, C. F. The Acetylene Electric Flame (*Elec. World*, March 8).

Pearce, S. L., and Ratcliff, H. A. Recent Developments in the Street Lighting of Manchester. (Paper read before the Institution of Electrical Engineers, London, March 6, 1913.)
Ein Quecksilberdampflampe für 500-600 volt (*Z.f.B.*, March 20)
Electric Searchlights (*A.E.G. Journal*, March).

GAS, OIL, AND ACETYLENE LIGHTING.

Albrecht, A. Gasstarklicht und Gasstarklicht-Beleuchtung (*Licht u. Lampe*, Feb. 15).
Prassgas oder Bogenlicht für Strassenbeleuchtung (*Z.f.B.*, March 13).
Vom Wettbewerb Zwischen elektrischen und Gasstarklicht (*J.f.G. Masch.*, March 30).
Ashof, C. Einfluss tiefer temperaturen auf Luftgas (*Z.f.B.*, March 20).
Böhm, C. R. Das Problem des festen Glühkörpers (*J.f.G.*, April 5.)
Editorial. High Pressure Gas and Flame Arclamps in Manchester (*J.G.L.*, March 11).
Hodgkin, N. B. High Pressure Gas Distribution (*J.G.L.*, March 25).
Schaller, R. Ueber das Verhalten von Gasglühlichtzylindern auf der Flamme (*J.f.G.*, April 5).
Riedl, R. Neuzeitliche Kunstformen und Wandlungen (*J.f.G.*, March 22).
Thorp, F. The Mixing of Gas and Air for Lighting and Heating (*J.G.L.*, April 8).
Van Goetham, J. C. The Manchester Streetlighting Tests (*G.W.*, March 22).
Webb, W. Gaslight in the Manufacturing Plant (*Am. Gaslight Journal*, March 10).
Gas and Scientific Illumination (*Brit. Co. Gas Assoc. Bull.*, March).
The Lights of South London (*J.G.L.*, Jan. 21).
Fortschritte auf dem Gebiete der Gaszünder (*Z.f.B.*, March 20).
La Lampe à Petrole Plaissetty (*Monsieur de l'Industrie du Gaz.*, &c., March 15).
Semi-indirect Gas Lighting (*J.G.L.*, March 11, April 1).
Manchester Street Lighting Experiments (*J.G.L.*, March 11).
Die Beleuchtung von Seminarbauten (*J.f.G.*, March 1).
Gas Lighting of a Bowling Alley (*Am. Gaslight Journal*, March 10).
The National Gas Exhibition (*J.G.L.*, March 18).
Simple and Effective Gas Signs (*J.G.L.*, April 8).
High Pressure Lamps for Advertising Purposes (*J.G.L.*, Feb. 25).
Silica Cups for High Pressure Lamps (*J.G.L.*, Feb. 25).
Village Lighting by Acetylene (*Acetylene Lighting and Welding Jour.*, March).

CONTRACTIONS USED.

E.T.Z.—*Elektrotechnische Zeitschrift.*
G. W.—*Gas World.*
J. G. L.—*Journal of Gaslighting.*
J. f. G.—*Journal für Gas- und Wasserversorgung.*
Z. f. B.—*Zeitsehrift für Beleuchtungswesen.*

Baker Street, London, W., Illuminated by Osrams.

OSRAM Lamps are now used for this purpose in over 200 Towns in Great Britain alone.
Cheap first cost.
Low maintenance expenses.

No other electic lamp is stonger.

The General Electric Co., Ltd.
Head Office: 67, Queen Victoria Street, London, E.C.

Street Lighting
by
OSRAM
Drawn Wire Lamps

TRADE NOTES.

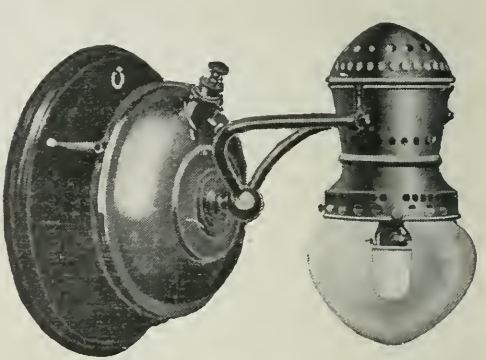
[At the request of many of our readers we are extending the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

The Kelite Domestic Portable Lamp.

From the **Kitson Empire Lighting Co., Ltd.** (Stamford, Lincolnshire), we have received particulars of the Kelite domestic lamp, two examples of which are shown. These lamps burn oil vapour in conjunction with an incandescent mantle, and are stated to give 100 c.-p. It will be observed that the oil reservoir occupies but little space, and the weight, with oil, in the two cases is only 8 and 9 lb. respectively.

In these days of increased illumination there is a distinct demand for high candle-power portable lamps, and the incandescent oil system certainly deserves attention. It is stated that a Kelite lamp will give 100 c.-p. for sixteen hours for a cost of one penny; whereas the cost with duplex wick lamps would be quite four times as much.

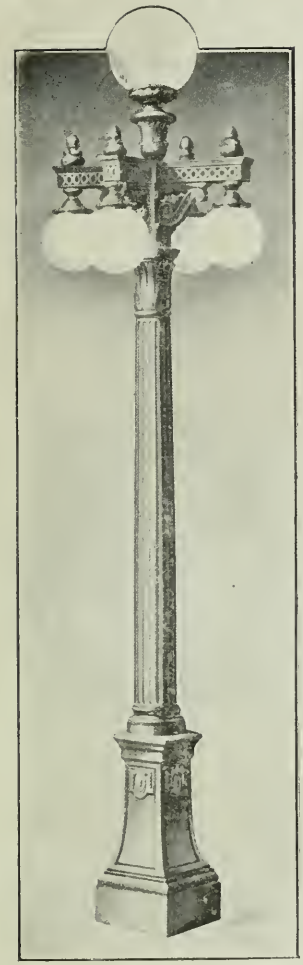


Two types of Kelite Lamps.

Contracts for Tantalum and Wotan Lamps.

We are informed that during the last few months some very large contracts for Wotan lamps and tantalum traction lamps have been filled by **Messrs. Siemens Bros.** (38 and 39, Upper Thames Street, London, E.C.). The whole of the cars of the Birmingham Corporation tramway system are to be lighted with some 20,000 tantalum lamps during the next twelve months, upwards of 30,000 Wotan lamps are on order on the South African railways, and 125,000 filament lamps are to be used on the L.C.C. tramways. In addition lamps are being used at Luton, Llanelly, Dartford, Carlisle, Leamington, Wolverhampton, Croydon, Warwick, Nottingham, and Derby. In fact, nine-tenths of the tramways of Great Britain are equipped with tantalum lamps of the traction type.

The **G.E.C.** 'Bulletin,' No. 5, 'Stage and Theatre Lighting.'—Theatre lighting has now become a special art, and sectional catalogues dealing with the subject are distinctly useful. The list now issued by the G.E.C. contains everything that is necessary—stage arc lamps, searchlights, bunch lights, battens, lamps for the orchestra, metallic dimmers, &c.



The "White Way" System of Street Lighting.

Most of us have heard of the so-called "White Way" system of street lighting prevalent in the United States. This method, we are informed, is now being developed by the British Thomson-Houston Co. in this country. The figure shows a typical post of this kind. It has four arms, which support Mazda lamps of 60–200 watts in Alba diffusing globes, the whole being supported by an ornamental Ionic pillar. This ornamental style of lighting has found special favour in many American cities.

A Pedestal Semi-Indirect Gas Fitting.

The illustration shows an interesting form of semi-indirect gas fitting introduced by **Messrs. W. Sugg & Co.** (67, Regency Street, S.W.). We have previously referred to several semi-indirect fittings designed by this firm, but the pedestal idea is distinctly novel, and should be very easy to apply in connexion with gas. This fitting is specially fitted for use at the foot of stairs, in halls, &c., and can be fitted with either one, two, or three inverted burners. The light is completely screened from the eye.

THE

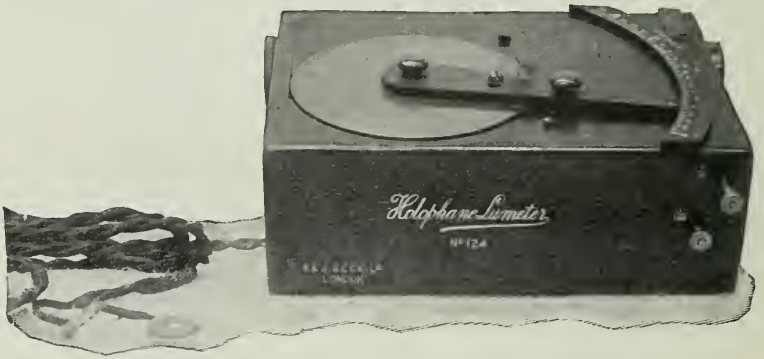
Holophane Lumeter.

The simple, portable, and accurate apparatus for measuring illumination, surface-brightness, or reflecting power.

Can be carried from place to place with the ease of a small hand camera.

Dimensions only $5\frac{3}{4}'' \times 4\frac{1}{2}'' \times 1\frac{3}{4}''$; case and accumulator supplied.

Measurements from 0·01 to 2000 foot-candles can be made.



Showing general appearance of new model of Holophane Lumeter.
(Dimensions : $5\frac{3}{4}'' \times 4\frac{1}{2}'' \times 1\frac{3}{4}''$.)

The Holophane Lumeter is of value not only to lighting engineers, but to architects, medical officers, factory inspectors, photographers, and many others.

Among the users of this instrument may be mentioned :—

The House of Commons, The Home Office (Factory Dept.), The London County Council, General Post Office, Great Western Railway, L. and S.W. Railway, Underground Railways, The Gas Light & Coke Co., St. James and Pall Mall Electric Supply Co., The Union Electric Co., The British Thomson-Houston Co., &c., &c.

For all particulars apply to

HOLOPHANE LTD.

12, Carteret St., Queen Anne's Gate, S.W.

INDEX.

MAY, 1913.

Subjects.	Authors.	PAGE
Economic and Hygienic Advantages of Good Illumination, The	L. GASTER	280
Editorial	L. GASTER	235
Illuminating Engineering Society :—		
Report of Meeting on April 15th		239
New Members		240
Notice of Annual General Meeting		240
Short Notes on Illuminating Engineering		285
Standard Clauses for Inclusion in a Specification of Street Lighting	A. P. TROTTER ..	241
Discussion :— Bell, Dr. L. (p. 275)—Bloch, Dr. L. (p. 272)—Clark, J. G. (p. 266)—Darch, J. (p. 270)—Edgcumbe, K. (p. 269)—Goodenough F. W. (p. 260)—Harrison, Haydn T. (p. 261)—Marks, L. B. (p. 276) Millar, P. S. (p. 278)—Rumi, Prof. S. A. (p. 274)—Sharp, Dr. C. H. (p. 277)—Terneden, Dr. L. J. (p. 274)—Thorp, F. (p. 261)—Trotter, A. P. (p. 253)—Watson, R. (p. 262)—Wilkinson, H. T. (p. 274).		
Review of the Technical Press		287
Trade Notes		290

B. T. H. Exhibits at the International Kinematograph Exhibition.

(Held at Olympia, March 22–29, 1913.)

At the stall of the British Thomson-Houston Co. a variety of indirect and semi-indirect fittings were shown. There were also special stage appliances, such as B.T.H. "dimmer," and the "flood" and "lens" stage arc lamps.

Another novelty was the exhibition of a special concentrated filament Mazda lamp. This is made in three sizes for 50, 100, and 200 watts, and in voltages ranging from 12–100. The filament is made of drawn tungsten wire, wound in a very narrow spiral, and bunched closely together so as to get a very high candle-power in small compass. This new lamp is expected to be of great service in connexion with motor head-lights, lanterns, and cinematograph projectors, &c.

LIGHT AND ILLUMINATION

Their Use and Misuse

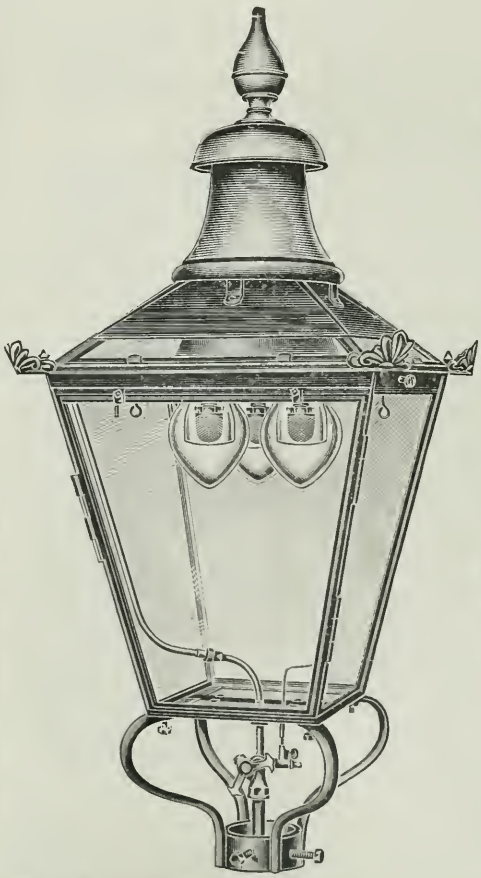
(*Reprinted from* THE ILLUMINATING ENGINEER, *December*, 1912.)

A FEW GENERAL RECOMMENDATIONS ON LIGHTING

Single copies are available at a cost of 3*d*. each. Larger numbers for propaganda purposes can be obtained at reduced rates.

Application should be made to:—

THE ILLUMINATING ENGINEER,
32, VICTORIA STREET,
LONDON, S.W.



PUBLIC LIGHTING

Fig. No. 7.

3-LIGHT PATENT INVERTED STREET LAMP.

This Lamp is of very high candle-power, interchangeable, made in parts, having angle burners of heavy cast yellow metal; gas and air adjuster on outside of lamp, inner cylinders, round or pear shaped globes, made for 2 or 3 burners, bye-pass in head of lamp.

A. E. PODMORE & CO.

Gas Lighting Patentees, Engineers and Contractors.

34, Charles St., Hatton Garden

LONDON, E.C.

Telegrams: "PROMEROPE, SMITH, LONDON."
Telephone No.: 6600 CENTRAL.
A.B.C. Code, 5th Edition used.

The ILLUMINATING ENGINEER
ELECTRICITY · ACETYLENE · OIL · GAS
Edited by LEON GASTER

THE JOURNAL OF SCIENTIFIC
ILLUMINATION.
OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London, 1909.)

ILLUMINATING ENGINEERING PUBLISHING COMPANY, LTD.
PUBLISHING OFFICES :—ATHENÆUM PRESS 13, BREAM'S BUILDINGS, LONDON. E.C.
Tel. No. 2120 Central.
EDITORIAL OFFICES :—32, VICTORIA STREET, LONDON, S.W.
Tel. No. 5215 Victoria.

EDITORIAL.

The Standard Specification of Street Lighting.

In the present number the discussion of Mr. Trotter's able paper on this subject is concluded.

A great diversity of views has been expressed, and much information collected, but most of the points raised had previously come before the notice of the Committee (although, perhaps, not expressed in such a detailed form). Some form of compromise, will no doubt have to be devised when the specification is referred back for reconsideration. Meantime there are several facts that we should like to emphasize. It the first place let it be understood that the specification should be, as Mr. Trotter remarks, *general* and not parochial. To be of real value it should apply to towns all over England, and even throughout the world. It is only reasonable to suggest that many previous specifications, although deservedly successful in particular districts, have not this general character, and could not be adopted wholesale. Under the circumstances any specification that meets with general approval must be in the nature of a compromise.

The next point to be observed is that the specification, while naturally framed to meet the present conditions, should also be schemed out with a view to the future. Some scope for ingenuity on the part of the contractor should, therefore, be allowed. We think that this aspect has been somewhat overlooked by some of the speakers in the discussion. It has been suggested for example, that the specification of a minimum illumination, of say, one-tenth foot-candle for a certain class of street would encourage people to arrange the lamps in such a way as to provide only this value for the entire street, and consequently to present the consumer with a much smaller total candle-power than at present. Needless to say it is at the moment almost impossible to do this, and in practice the variation factor in a street-lighting is always considerable. This was doubtless appreciated by the Committee in their classification. It is conceivable that in the future, improved methods of shading and more scientifically designed street reflectors might enable light to be distributed much more evenly than at the present ; in this case the intention would surely be to provide the same or more illumination than at present but to make it less patchy. We agree that it might be wise to adopt a somewhat more definite wording of Clause 8 in the specification, providing for a statement of the polar curve of light distribution of the lamps used, as well as the minimum illumination. By some such method we might gain the advantage in principle of specifying illumination and yet provide for precise details as to the performance of the proposed illuminants as well.

Another point of which much has been made is the assumption that the illumination clause could only apply to 80 per cent of existing streets. We cannot help thinking that the percentage of illuminated streets in London, or in any big provincial town should work out higher than this ; or at least that a very small improvement would be needed to bring such streets into the A (min. 0·01 foot-candle) class. The specification is presumably intended for towns and not for small villages or country roads, which form a class by themselves.

For the moment we do not desire to say more on this subject. The specification is to be referred back to the Committee, we would only plead for a maximum of toleration among those interested, and the recognition that the present specification, if it contains some debatable clauses, also contains much on which there is already general agreement.

The Annual Congress of the Royal Institute of Public Health.

The Congress of the Royal Institute of Public Health, held in Paris during Whitsun week, was the occasion of a number of excellent papers being read on general hygiene. The new section dealing with industrial hygiene, should be of special interest to our readers. This was presided over by Sir Thomas Oliver, who himself presented a most suggestive communication on Occupational Fatigue. In the course of this paper Sir Thomas showed how the duration of life is apt to be shortened by work of a harassing nature, and alluded to the strain imposed in the supervision of modern fast driven machinery. The effects of temperature and humidity in workshops were dealt with by Drs. Langlois and Boulin respectively.

It was natural that illumination should receive some attention in this new section devoted to industrial hygiene. A discussion on 'Lighting as a Health Factor in Occupation and its Influence on the Prevention of Industrial Accidents,' was opened by the author, and Dr. Broca discussed the hygiene of vision, with reference to modern illuminants. The writer took the opportunity to summarize some of the work done by the Illuminating Engineering Society in this country. It was pointed out that measurements of illumination have become quite practical and trustworthy. As an illustration the author exhibited a British instrument side by side with the photometer devised by Prof. Blondel, and it was shown that the results obtained with both forms of apparatus were in substantial agreement.

Among other papers of this section, we should like to make specific reference to those of Dr. S. M. Murray and Mr. Aubrun, who pointed out the close connexion between nystagmus in mines and deficiency of illumination or surface brightness. The papers dealing with illumination were very well received, and there is no doubt that the justice of our claims in this respect invariably made a deep impression.

Such Congresses as this may achieve excellent results, if judiciously guided. The social intercourse they render possible is a very important factor, perhaps even more so than the actual papers. The hospitality and characteristic charm of our friends in France were exerted to the full, and everything possible done for the enjoyment of the visitors. We feel sure that the British members will carry away pleasant recollections of their visit. But in order to render these gatherings a success it is essential that the visitors should study the susceptibilities of their hosts, They should be specially careful to avoid anything in the nature of "showing off." A demonstration that may appear natural and dignified at home, may easily border on the ridiculous abroad.

These are points that Organizing Committees should bear in mind at future Congresses.

The Prevention of Industrial Accidents.

We observe in a recent number of *The Times Engineering Supplement*, a most interesting account of the methods now adopted by a number of the great American companies, with a view to the prevention of industrial accidents. For example, the United States Steel Corporation has appointed a permanent Central Safety Committee, which holds quarterly meetings and makes thorough inspection of the plants of the subsidiary companies. There are also local Safety Committees in different parts of the country on which the workmen of the firm are strongly represented. It is satisfactory to learn that the workpeople themselves have taken this matter up very keenly, recognizing that the work of the committee is primarily for their benefit, and are often responsible for valuable practical suggestions.

The writer of this article in *The Times* states that as a result of sixteen months' work on the Chicago and North-Western Railway, there has been a decrease of 31·5 in the number of employees killed, and 32·2 per cent in the number of employees injured. There has also been a substantial decrease of the number of passengers killed and injured. We understand that the idea of Safety Committees is being taken up by quite a number of companies in the States.

We should like to point out the great possibilities of voluntary work of this kind, accomplishing as it does much that cannot readily be done through official government supervision.

For example, it is only in exceptional circumstances, *e.g.*, when there is a legal dispute or loss of life, or a serious case, that factory inspectors make a systematic inquiry into the causes of an accident. Many mishaps of a not very serious nature are not inspected. It would be an excellent plan for the Safety Committees to undertake the systematic classification of accidents. If this were done much useful information would be elicited as to the part played by defective lighting in causing mishaps, and we should soon discover the conditions responsible.

The American Museum of Safety in New York has now a special section dealing with lighting, and the writer, during a recent visit to the States was given to understand that more will be done in this respect shortly. When the Safety Museum is arranged in this country we hope that a special section, showing the connexion between good lighting and the prevention of accidents, will be established.

LEON GASTER.

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of 'The Illuminating Engineer.'

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

A Night Golf Putting Course.

By T. J. Litle, Jun.

Last year an article was published describing the layout of the lighting of the Tennis Courts at the Woodbury Country Club, Woodbury, New Jersey, U.S.A.

This installation proved so popular that it occurred to the writer that it would be a good scheme to extend this field of artificial illumination to include the lighting of a golf putting course. Such courses have been in vogue for some time, but hitherto their usefulness has been limited to the daylight hours.

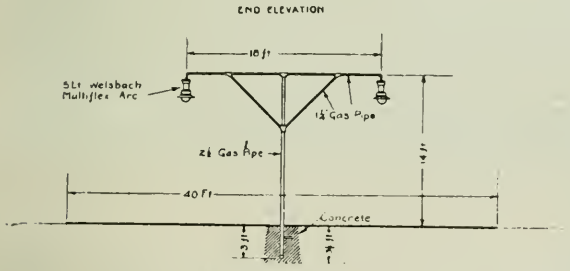


Fig. 1.—Diagram of Gas Piping for Night Golf Illumination using 5 lt. Welsbach Multiflex Gas Arcs.

The course is laid out on a plot of ground 40 by 80 ft. as shown in the accompanying diagrams, and contains nine holes. The grass is trimmed closely as on a putting green. The courses were originally intended for practising putting, but are now being used extensively for matches.

The advantages of night-play on such courses is evident. Artificial light makes it possible for business men and others who have not sufficient time at their disposal during the day to practice putting at night.

The area to be illuminated is comparatively small. It is, however, possible for twelve persons to use the course at the same time, and putting by night has already proved to be an extremely novel and popular recreation. A night tournament has recently been played.

The installation of the lamps is comparatively simple. Two wrought iron posts made of 2½ in. iron pipe as shown by diagram are used and two lamps are suspended from the ends of a long cross arm on the top of the posts.

Four 5-mantle Welsbach Multi-Flex Inverted gas arcs are required to light the course. To reduce glare opaline globes were used on the lamps.

A fairly uniform distribution of light over the course is desirable, the principal requisite being to have the nine holes uniformly lighted. This was accomplished by spacing the holes so that they were not more than 10 ft. horizontally distant from the lamps.

The lamps are equipped with standard distributing reflectors, spreading the light over an area considerably greater than the putting green, for it was found that the players not only desired to play on the course itself, but to approach with a mashie, and it is possible to do this at a distance of at least 100 ft.

The intensity at various holes is approximately 2½ foot-candles. The holes are painted white inside to make them easily visible from any part of the course. The illumination provided is considerably higher than that usual on the floor of an ordinary house at night, and is remarkably uniform. The photograph shown in Fig. 3 was taken by the light of the

lamps alone on a dark night, the exposure being $1\frac{1}{2}$ minutes.

It will be noted that the golf ball, which is white, is clearly distinguishable in the picture. Fortunately, from the illumination standpoint, there is a good contrast between the white golf ball and the grass. The writer has been able to distinguish the ball easily on this green at a distance of 200 ft. from the course.

The day photograph (Fig. 2) shows the scheme of installation. The posts are painted white to match the gas arcs, which are finished in white enamel steel, ornamented with gold bands. In this photograph it will be noticed the gas lighted tennis courts are shown in the background. Night tennis proved quite an attraction last year at the club. The courts were crowded every clear evening, and there was always a number of players on the "waiting list." Business men who had not played tennis for several years because of insufficient time played there last year at night. It is interesting to note that during the past winter, there was a very severe wind storm in this locality which uprooted a number of large trees but did not bend ony of the poles.

The cost of lighting this golf putting course is $7\frac{1}{4}$ cents per hour for the gas consumed for the entire four lamps, each lamp consuming from 18 to 20 cubic ft. of gas per hour, the cost of gas in Woodbury being 90 cents per thousand cubic ft.

Electric Lighting: Cost in 1896 and 1912 Compared.

THE diagram below, extracted from the *A.E.G. Journal* for October, 1912, shows very clearly the remarkable reduction in cost of electric lighting within the last few years. Until the introduction of the Nernst lamp in 1900 electric lighting was a luxury, since then the demand has been steadily on the increase. The metal filament lamp has rendered it within the reach of every one.

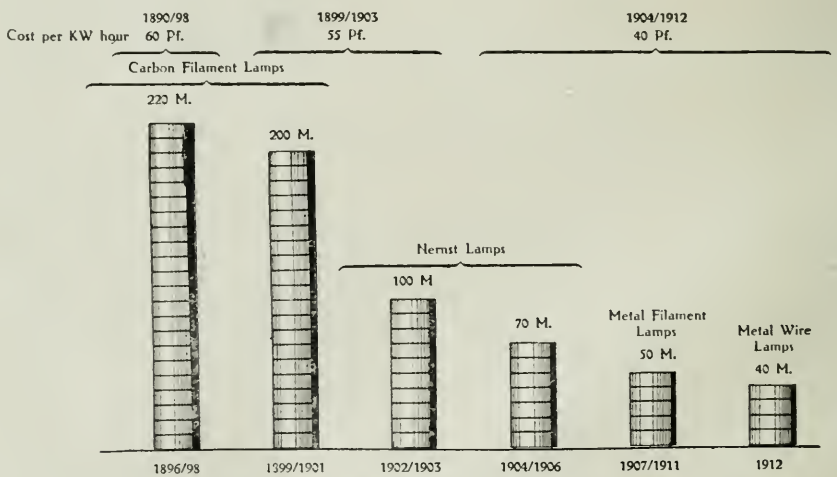
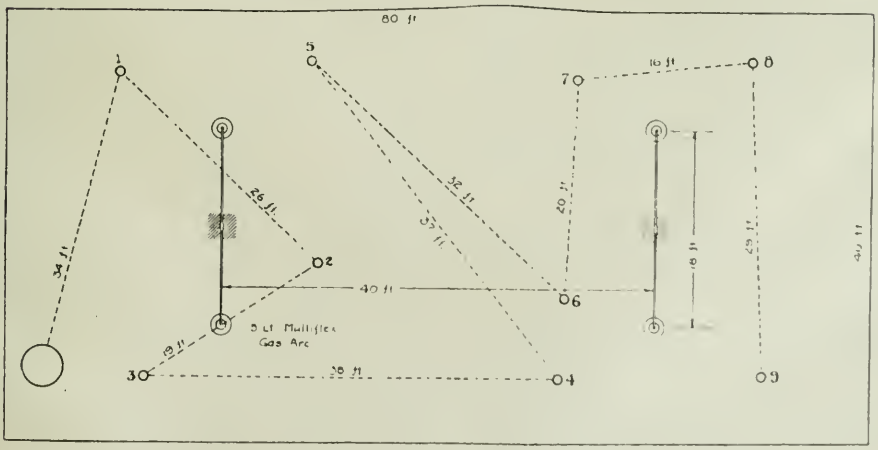


Fig. 1

According to this table the cost of lighting has been reduced from 220 to 40 marks, *i.e.*, to less than one-fifth of that prevailing in 1896!

FIG. 2.—View of putting green by daylight.

FIG. 3.—View of putting green taken by gaslight.



Holes lined with sheet copper painted white inside

FIG. 4.—Plan of green showing piping arrangements.

Illumination: A Field for the Optometrist.*

By Howard D. Minchin, Ph.D., Rochester, N.Y., Professor of Physics, the University of Rochester.

The rapid growth of our cities, the phenomenal development of our great factories, and the enormous increase in the amount of work done by machinery are steps in our civilization that have brought to us the important problem of artificial illumination.

The magnitude of the problem is evidenced by the fact that it has given rise to a special branch of engineering, namely, that of illuminating engineering.

The illuminating engineer is a product of the demands made upon the human eye by our modern methods. He has done his work so well that there is no longer any doubt regarding his permanency with us. His problem is a new phase of the engineering field, and it is no easy one. It is confined within no narrow limits.

The principles of illumination are based upon vision and the distribution of light. The problem of artificial illumination comprises the consideration of (1) the source of light, that is, the illuminant; (2) the flux of light issuing from the illuminant; (3) the distribution of the light flux in space, that is, the light flux density, and particularly the light flux density at the illuminated object; (4) the illumination, that is, the light flux density reflected by the illuminated object and the effect produced upon the eye.

In (4) we get into physiology and away from physics, and our knowledge is much more limited than it is in physical science.

Illuminating engineering embraces a field that involves in a high degree two different sciences—physics and physiology.

The light flux entering the eye is varied in its physical quantity by the reaction of the eye on the light entering it, that is, the eye, by the contracting or expanding of the pupil, controls within limits the amount of light entering.

The effect of the light flux entering the eye depends upon the fatigue of the eye, and also upon the colour of the light.

Comfortable acute vision requires abundant illumination of the proper quality, distribution, and direction.

The illuminating engineer has much more to do than furnish the proper light flux. His problem is much greater than the mere filling of a given space with a given amount of light. Often we find illumination which seems to be quite unsatisfactory, trying to the eyes, and uncomfortable when the density and the distribution of the light flux seems satisfactory. This is due to the fact that some fundamental physiological requirement is violated.

The illuminating engineer must consider the physiological effects. The principal ones being contraction of the pupil of the eye. Points of high brilliancy in the field of vision are a waste of light flux, and result in discomfort to the eye. The eye should not be exposed to direct rays of a light of high intensity, such as, say, the light of the tungsten filament or the arc light. Cutting down the light flux of the illuminant often increases the light flux entering the eye. Fatigue is another physiological effect to be reckoned with. Sensitivity of vision enables us to see equally well with illumination varying in intensity from one to 10,000. Both the above effects are similar in action. They both reduce the physiological effect for high intensity. The first one works more rapidly than the second.

---

* Reproduced from *The Optical Journal*, New York.

The eye fatigues when working constantly in a room of high uniform illumination. It seems better to have the room not uniformly illuminated. Have high illumination where it is needed, and have the illumination low where it is possible.

Fatigue at high intensity occurs far more with yellow and orange lights than with white, and it occurs very little with green and bluish-green.

Irritating effects of fatigue are most felt in artificial illumination, because of the preponderance of the yellow and orange rays.

The next physiological effect to be noted is that of differences. The use of shadows in illuminating requires a directed light. Diffused light will not produce shadows. A perfectly diffused illumination is then unsatisfactory. and a directed light is also unsatisfactory. It suffices, if there is sufficient directed light, to mark the edge of the objects, and thus enable the eye to distinguish more clearly. In a drafting-room, where shadows are objectionable, a perfectly diffused light is required.

Diffused illumination and no shadows is bad for flour mills or for foundries. Here all the objects tend to have the same colour, and there is no contrast.

The maximum of the sensitivity of the eye shifts with decreasing illumination from the yellow to bluish-green, and where a low intensity is used, as in street lighting, a source of light rich in the shorter wave lengths; that is, a white light source is superior in its physiological illuminating value to a yellow light source.

Some of the problems presented by artificial illumination are: (1) What is the standard by which we are to test the quality of the artificial illumination? (2) What is the best illumination for a given work? (3) How can this illumination be produced in quality? (4) How can the proper distribution be effected? (5) What illuminant is to be used for any given condition?

The effect of the intensity of illumination upon the sensitivity of the eye is very important, as it determines the colour shades most effective for any particular purpose.

Sensitivity to contrast is another factor that comes into our problem. Visual acuity largely depends upon contrasts in luminosity. Unsteadiness of illumination is one of the great sources of eye trouble. Another source of many disorders is the excessive amount of the shorter wave lengths that is present in some of the artificial illuminants.

These problems and conditions of artificial illumination involve considerations that are hygienic, æsthetic, physiological, psychological, and physical. There are problems for the architect, for the illuminating engineer, for the doctor, for the physicist, and for the optometrist. Problems for any and all interested in vision and its conservation and relief.

In this paper it is my one desire to emphasize the urgent call that artificial illumination, with its problems, is making upon the optometrist.

The problems are not to be solved by any one group of the above-named groups. If they are ever solved it will be by the co-operation of all the groups. The eye specialist must contribute his share, or the results will be just so much the weaker, and he will be just so much the weaker, because he did not cultivate his opportunity.

I do not wish to increase the load that any one must carry, but I am interested in having the optometrist face his responsibility, and in that responsibility find his splendid opportunity. I fully appreciate the vast field of knowledge a man must face, and I know that one cannot be well equipped in all lines of work. I do not, on the other hand, desire to see a man become so much of a specialist that he really hampers his efficiency for greater work by having a little skill in a smaller field. I advocate, rather, a skilled equipment in some one chosen field, and then enough information concerning related subjects to add to his efficiency in his one line.

Such a field as illumination surely deserves a place in the curriculum of the eye specialist.

The Lighting of Bethnal Green Museum.

By An Engineering Correspondent.

On the way to the Bethnal Green Museum, in the month of May in this year of grace 1912, a man passed by riding one of the old high "ordinary" bicycles, ordinary no longer—indeed most extraordinary any time this last twelve years. A portent, truly, of other survivals, relics of an old-time idea of lighting, to be seen within.

The Museum at Bethnal Green is an off-shoot of the Victoria and Albert Museum at South Kensington, and, like it, has for many years been under the control of the Board of Education. The very structure was once a part of the parent building, the iron and brick, before they went eastward forty years ago, having been known to the London of that day as the "Brompton boilers." With the building went the gas lighting—the brilliant illuminations of the early exhibitions—and the apparatus of this is still in position, long bars and large pendant rings with burners every two or three inches to give the long lines of flaring jets such as still flicker and flame outside many a provincial butcher's shop.

But, though these lights are no longer in use, much of the existing system must have attained its majority years ago, and have earned an honourable retirement which seems slow in coming.

The "well," or centre portion of the ground floor, which is first entered, is 170 ft. long by 40 ft. wide, and is open to the louvred roof. The day lighting is good, and at night this is adequately replaced by a central row of four 7½ ampère open-type arc lamps, at a height of about 19 ft., aided by one self-intensifying gas lamp which has apparently supplanted a fifth arc in the middle of the row. Some little additional light is also received from the sides of the well from the lamps in the upper galleries. The arcs hang on counter-weights to admit of easy trimming, and the wiring to them is carried on insulators fixed to the tie-rods of the roof.

By ascending a few steps the lower of the side galleries is reached. Here many of the smaller exhibits are arranged —foodstuffs and human hair, stuffed birds and leather shoes, and other things as varied. For the most part they are in 6 ft. glass cases, but with cases of the desk type round the sides. By day the light is obtained from windows in the outer wall on the one side, and from the roof above the well on the other. As the gallery on either side is over 40 ft. wide, with a ceiling only about 14 ft. high, it is not to be wondered at that the centre is anything but well lighted in the daytime. The upper gallery (which forms the ceiling of this floor) is carried on two lines of iron columns, which divide the width into three equal spaces, and the artificial illumination is provided by a three-light bracket fixed on each of these columns at a height of 8 ft. There are twelve of these columns in each row, and there are in addition 3 two-light brackets on the end wall.

The lamps used in these brackets are still carbon filament ones, and the lamp-holders in use are a proof of the antiquity of the installation, for they are of the hook-and-spring type, with brass side-terminals for connecting—a type probably unknown to the present generation of wiremen, although apparently lamps for use in them are still on the market. The wires are brought up through the floor from two cut-outs in the basement, and turn into the hollow column from which they enter the tubing of the fitting; they are then brought out through holes in the brass near the holders to be connected to the side-terminals. The centre point on each three-light bracket has now been

fitted with a bayonet lampholder—perhaps the beginning of the end.

The cases in the immediate neighbourhood of each bracket are only fairly well lighted, but those along each side (generally those seen best in the daytime) are very poorly provided for, if, indeed, it can be considered a provision at all.

Whatever may have been thought of it when the installation was first fitted up, the lighting in this part (an allowance of one 16 candle-power lamp for about each 90 square feet of floor space) by no means comes up to modern requirements; nor would the substitution of metal filament lamps of equal wattage meet the difficulty without a considerable rearrangement or increase of lighting points.

Two or three cases under the wall-brackets at the end are well provided for, but the narrower cross portion connecting the northern with the southern side-galleries at their eastern ends is very dim and shadowy.

Ascending to the upper gallery the collection of pictures, porcelain, and furniture is reached. There are no side windows on this floor, the daylight being obtained from the roof and the end windows—the lower parts of the latter being utilized for the display of a little stained glass (which, however, has not been arranged for artificial lighting like the Pierpont-Morgan specimens at South Kensington). The general illumination, both by day and night, is very satisfactory, except that, in the latter case, there are occasional dark sides to cases or a shadow of the heavy top framing of a case on the statue it contains. Taking the galleries on the north and south sides together, and adding the connecting galleries at either end, there is a total floor-space of about 17,000 square feet, and this is served by twenty $7\frac{1}{2}$ ampère open-type arc lamps at a height of 13 ft. This is a consumption of just about half a watt per square foot, but a little assistance has been obtained from gas lights at three or four weak points.

One or two special exhibits are also lighted independently, as, for example, a room in a Japanese house, which receives light from two 15 in. squares in the ceiling covered with muslin, behind which incandescent electric lamps are placed. A room from a house in Damascus has a lamp in its Oriental hanging lantern, but, as this would be insufficient for occidentals to study the details of the room by, further lights have been added concealed from the student's eye.

A much less satisfactory state of affairs exists in the basement. The centre block is occupied by offices and stores; the exhibition galleries around these vary in width from 14 ft. to 40 ft., with a ceiling only 11 ft. high. The day lighting, especially on the northern side, is so bad that assistance is required from sundry incandescent gas brackets and a few electric pendants over one or two side cases all day long.

The northern gallery, which has a more or less uniform width of 30 ft., contains bulky objects and cases of textile fabrics and furniture, reaching almost to the ceiling in some cases, and at the eastern end bronzes and other dark metal-work. The illumination, therefore, was a difficult matter to deal with economically, and the only efficient treatment would have been by a considerable number of fair-sized points or by strong inverted lighting. H.M. Board of Education seems to have thought otherwise, for they have installed a line of thirteen 300 c.-p. self-intensifying gas lamps at 9 ft. from the floor. Had the ceiling been double the height it is, so that the lamps could have been hung at a fair height, such a method might have been permissible, but they are now often shut in by exhibits and are unable to spread their light evenly. The ends of most of the cases furthest from the windows are certainly better lighted by night than day, but the direction of lighting on the statuettes, &c., is directly reversed.

A big spring-cleaning and repainting of the whole museum was recently carried out, and it seemed a pity that no advantage was then taken of the opportunity to bring the lighting up to date. Perhaps its position in the East-End makes the officials regard it as a sort

of Cinderella, content to put up with anything it can get. In proportion to its size it is much better patronized by the public in the evenings than the great blocks of buildings at South Kensington, due largely, no doubt, to its being situated right amongst the dwellings of the people (and presenting a marked contrast to those dwellings in spaciousness and warmth and even light), instead of standing in a district sparsely inhabited by the wealthy class. For, although South Kensington is easily "getatable," it is not within walking distance of a very large population, and there are thousands who, though interested in works of art and science, can ill afford any unnecessary sixpenny return fares—especially when, as the saying is, "every penny cake costs twopence," or twopence plus an indefinite number of halfpennies.

Forthcoming Congress of the International Petroleum Committee.

THE third meeting of the International Petroleum Committee is to take place in Bucharest from October 12th to 20th next, under the patronage of the Roumanian Government. Besides the members of the International Committees, various scientific institutions and corporations have been invited to be present. Among the points to be discussed are the analytical study and nomenclature of petroleum products, storage and transport.

Another proposal of considerable interest is that an International Institute of Petroleum should be founded in Bucharest. This suggestion will be brought forward at the coming Congress. It is intended to make this Institution an international centre of information and research for the benefit of scientists from foreign countries and all those interested in the petroleum industry.

New Members of the Society.

THE names of the applicants for membership, read out at the previous meeting on April 15th, have now been formally announced for the second time, and these gentlemen were declared Members of the Illuminating Engineering Society. In addition, the names of the following gentlemen have been duly submitted and approved by the Council, and were read out by the Hon. Secretary at the meeting of the Society on April 29th :—

Honorary Members—

Warburg, Prof. Dr. Director of the Technische Physikalische Reichsanstalt, Charlottenburg, Berlin.

In recognition of distinguished services as Director of the Reichsanstalt and as the First President of the German Illuminating Engineering Society.

Whitelegge, Sir Arthur, K.C.B. H.M. Chief Inspector of Factories, Whitehall, London, S.W.

In recognition of valuable services in promoting the study of industrial illumination.

Corresponding Member—

Liebenthal, Dr. E. Technische Physikalische Reichsanstalt, Charlottenburg, Berlin.

Ordinary Members—

Berridge, T., *A.M.I.C.E.* Engineer, The Gas Works, Leamington Spa.

Eisenmenger, H. Nela Buildings, East Cleveland, Ohio, U.S.A.

TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London. 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

Standard Clauses for Inclusion in a Specification of Street Lighting.—By A. P. Trotter.

ADJOURNED DISCUSSION at the Meeting of the Society on Tuesday, April 29th.

[This paper was presented at a Meeting of the Society, held at the House of the Royal Society of Arts, on April 15th, a special invitation being issued to Members of the Institution of Electrical Engineers, Institution of Gas Engineers, and Institution of Municipal and County Engineers to take part in the proceedings. The Discussion was resumed at a second meeting on Tuesday, April 29th.]

Mr. F. W. Goodenough said that, as the object of the meeting was to endeavour to arrive at a practical result, those who had criticisms to make on this specification could most usefully make them early in the discussion rather than later, so that subsequent speakers could reply to or discuss any of the points that were raised; and as he himself happened to be one of those who had criticisms to make of the specification, it might be useful if he made them at once. In doing so he spoke, not as Chairman of the meeting, but as one interested in street lighting who desired to give his views on the specification. It appeared to him that the requirements for a specification on which to invite tenders for street lighting were as follows :—

1. It ought to be framed on a basis easily comprehensible by members of local authorities.

2. It should, if possible, have as a standard something with which "the man in the street" is familiar and can understand.

3. It should be of general, not limited, application.

4. It should be so framed that it is not open to being interpreted in such a way that the lighting of a street is reduced to an absurdity whilst the specification is strictly complied with.

5. It should leave nothing to the discretion of the contractor, *i.e.*, when tenders are opened they should be in every respect on identical bases, so that the respective prices can be tabulated and directly compared. There should be no qualifying or descriptive clauses which leave to the members of the Committee or Council dealing with the matter the decision of whether the scheme set out in tender A or that in tender B would prove the more satisfactory scheme for the lighting of the streets in question. Otherwise the whole object of adopting a "standard specification" would be defeated, and

we should get back to the old unsatisfactory position of having the comparative merits or demerits of two schemes of lighting discussed and adjudicated upon by a body of men having no knowledge that would qualify them for forming a sound opinion upon the subject, and of having the canvassing powers and local influence of the competing tenderers brought into action.

6. The provisions for making the tests to which the illumination provided by the contractor is to be subject, and upon which he is to be liable to penalty for deficiency, should be such as to secure as far as possible precision of result. The margin for possible error should be small. The method of testing should be as closely defined as possible.

In my opinion the draft specification fails to comply with any one of these requirements.

1. In regard to the first point—that of

Ease of Comprehension.

Not one councillor in a thousand knows, or could be made to understand intelligently and thoroughly, what would be meant by saying that the streets in his district were going to be so lighted that there would be a minimum illumination of 0·025 foot-candles on a horizontal plane at a height of 3 ft. 3¾ in. above the ground level.

Scientific formulæ and nomenclature are very pleasing and satisfying to the scientific mind. They are liable to be highly confusing and mystifying to the lay mind, and should never be used when the same result can be achieved by the use of simpler language.

The value of the Illuminating Engineering Society to the world of business will be in direct ratio to the scientific accuracy of the principles it enunciates in regard to questions of illumination, but in inverse ratio to the scientific jargon in which it expounds these principles.

To be appreciated we must be understood. If, then, we can get a basis that can be comprehended by the average Committee-man—I do not ask for the impossible, and say "by *every* Committee-man"—we shall have provided something much more practically useful than this specification gives us.

2. In regard to the second point—that of the desirability of

A Familiar Standard.

To get a basis of specification comprehensible by the man who wants light in the street, we should be wise to adopt a standard with which he is familiar.

Every one is familiar with the expression "a lamp of such-and-such candle-power." A thousand people—even members of a Lighting Committee—would have some fairly accurate conception of the difference between a 16 candle-power lamp and a 1,000 candle-power lamp, to one person who would have any conception whatever of a street with "a minimum horizontal illumination of 0·025 foot-candles."

Is there, then, any good reason why we should not adopt lamps of specific candle-power as the basis of a street lighting specification, and so comply not only with the second, but also with the third requirement I have laid down—that the specification shall be of universal, not limited application?

3. It is surely only a question of:—

(*a*) Specifying what is meant, for the purposes of the contract, by candle-power (this is already contemplated by the specification, and would, Mr. Trotter admits, have to be adopted in respect of 80—I should say 90—per cent of the streets and roads throughout the country); and

(*b*) Determining how many lamps of specific candle-power, on columns of (or suspended at) a specific height, placed at specific distances apart, are required to give illumination of desired grades—Class A, Class B, and so on.

This is the sort of proposition that a council or committee can understand. Their expert advisers may comprehend tests of minimum horizontal illumination defined in foot-candles, but the value of such observations has, it seems to me, been considerably overrated. It lies chiefly in providing a

means for expressing in precise figures, and checking, the observations of the eye as to the comparative degree of illumination—first, second, or third class—found in streets already lighted.

We must, if we are going to be practical, work, in these matters of illumination, by analysis before synthesis—we must take existing examples of lighting, see if they are good, bad, or indifferent, and then analyze the causes of the effects—and we only need these horizontal minimum illumination readings, in conjunction with maximum and average illumination readings to enable us to express the effects and to verify our "rule of eye" classifications.

If there had never been any street lighting, and we had started to plan scientific illumination for the streets on paper by calculated minimum horizontal illumination, who would have believed that most excellent and satisfactory lighting results could be obtained by a scheme which provided for a minimum horizontal illumination only one-twentieth of the maximum horizontal illumination?

Yet we know by experience that a diversity factor of 25 or 30 to 1 is compatible with thoroughly satisfactory illumination in the streets—illumination which to the eye appears uniform because of the imperceptible degrees of gradation.

A great deal is made by the advocates of the draft specification of the point that local authorities are out to buy "not lamps, not candle-power, but illumination." But this is surely only using words to confuse ideas. It is true that local authorities want to secure effect, but it is equally true that to obtain effect you must purchase the necessary cause.

When you feel hungry you are "out to buy" satisfaction of your hunger, but you do not go into a restaurant and order "minimum horizontal satisfaction." You know by experience what dishes go to make up a first, second, or third class dinner, and, according to the state of your purse or of your views upon simple life, you order the causes necessary to produce the desired effect. The inexperienced diner possibly produces "glare" in the eye as the result of his efforts; the experienced secures a satisfactory "diffusion." If a medical man is called in to the former he will doubtless prescribe a standard specification of diet, but it will be in terms of food, and not of "minimum dietetic satisfaction expressed in decimals of pulse-temperature."

The local authority wants illumination as an effect. To obtain that effect lamps of certain candle-power at certain heights and distances apart are needed. Why not say so?

If you do not, you fail to comply with the fourth and fifth of the requirements I have outlined.

4. You leave yourself open to the possibility of very small units of light being placed on very high columns wide apart, which would give the same minimum horizontal illumination as lamps of greater candle-power on lower columns at the same distance apart, or as lamps of the same candle-power on lower columns nearer together!

Taking Mr. Haydn Harrison's table on p. 16, we find that a specification calling for 0·01 foot-candle minimum illumination on a horizontal plane 3 ft. $3\frac{3}{4}$ in. above the ground in a street 2,100 ft. long would be complied with by the provision of (*a*) twenty-one 33 c.-p. lamps on columns 36 ft. high, or (*b*) twenty-one 95 c.-p. lamps on columns 10 ft. high, or (*c*) thirty 34 c.-p. lamps on columns 10 ft. high.

Who is going to say that the street would be equally well or equally satisfactorily lighted under all these different arrangements? Yet each of them is rendered possible by the draft specification, because it ignores maximum illumination, ignores average illumination, ignores gradation of illumination, and only takes into account minimum illumination.

Mr. Trotter says that "if the illumination is up to a certain specified standard, it does not concern the public whether it is produced by a few lamps of large candle-power or by more lamps of less candle-power, or whether tall or shorter posts are used, within certain limits." I should like to repeat that quotation to Mr. Trotter on a

foggy night in a street lit by lamps on high columns 100 yards apart!

Mr. Kenelm Edgcumbe no doubt, as a more than ever convinced "whole-hogger" for the specification, will say that a dismally lighted street is as desirable and admirable as a brightly lighted street so long as it has the same minimum horizontal illumination, but I should just like to quote in this connexion something which he wrote six years ago, in a paper on 'The Comparison of Street Illuminants.' He said:—

"Although to compare the minimum illumination may be a highly scientific way of treating the problem, at the same time street illumination has its æsthetic side, which is by no means less important than its scientific; and since it is the man in the street who pays the bill, his views have to be consulted. When asked which of two streets he considers to be the best lit he will inevitably declare in favour of the one which has, not the highest minimum, but the highest average illumination. It may not be logical, but the fact remains. [Personally, I do not see the failure in logic.]

"This point is well illustrated by a comparison, for example, of Oxford Street and Kingsway [he was speaking of the lighting that existed at that time] in which the minimum illuminations are much the same, but there can be no two opinions as to which street is the 'best lit.'

"Although an even illumination equivalent to the minimum permissible is no doubt scientifically what should be aimed at, on the other hand a street with a high average illumination, even though less evenly distributed, gives a much more pleasing impression; in fact, there is probably much the same difference as between what would be called a 'bright' day and a 'dull' day."

I commend these very practical and sound observations to the careful consideration of the municipal and county surveyors, who represent the interests of "the man in the street" (including the tradesman who wants his thoroughfare to be bright, not dull), and who would not want to be made a laughing-stock for their ratepayers by adopting a specification that, with its ultra-scientific eye, regards a street of dismal appearance as being equal to one of a bright and pleasing appearance—though I beg leave here to protest against the abuse of the word involved in calling such ideas "scientific" in any way. Science is organized knowledge, and the "science" that leaves out of account obvious facts and considerations has no right to the title.

Here I am glad to be able to quote from a communication the Society has received from Dr. L. Bloch of Berlin, who, in the course of some very interesting criticisms of the draft specification, gives it as his opinion that "the prescription of a certain minimum illumination alone is not sufficient to ensure a well-lighted street. The adoption of this prescription of minimum illumination would also exert a marked influence on the arrangement of a street lighting installation, and by no means a favourable influence. It would encourage the already prevalent, but injudicious method of placing lamps in the streets as high as possible; for it is common knowledge that by placing the lamps high one can, in general, get the best value of the minimum illumination, and the uniformity is also improved. But it is possible under these circumstances that there will be no single point in the street where the illumination is strong enough to read with ease."

I also find very strong support in the communicated views of Dr. Louis Bell, the well-known American authority on illumination. He says:—

"There is no objection, if anybody fancies the idea, to putting in a minimum illumination clause, provided nothing of any importance is made to hinge upon it, in which case it might as well be forgotten.

"The inevitable effect of a minimum illumination, which the contractor may furnish substantially according to his own plans, will be found to be the smallest total light flux which can be made to serve. A call for minimum illumination is practically a call for small gas or electric incandescents glimmering along the street at

intervals as infrequent as can meet the specification for illumination midway between them. These are not matters of theory, but conditions which will inevitably confront the municipality in undertaking its street lighting. It is my judgment, therefore, that an illumination specification can only prove useful when it has very little to do with the real considerations of the contract. I have always looked upon a contract for street lighting as essentially a contract for service, under specified conditions, with certain specified illuminants, of which the performance can be both definitely ascertained in the laboratory and easily checked on the street. It is the task of the engineer having the work in charge for the municipality to see what luminous sources and what arrangement of them will give him the illumination required in streets of various classes, and then to insist on the use of these illuminants under certain standard conditions which can be maintained. I have found in practice that specifications drawn on this basis produce good results with extremely little friction between the contracting parties."

5. The fifth requirement laid down for an ideal specification, that it should

Leave Nothing to the Contractor

other than the choice of the lamp, of specified candle-power, needs little to be said to commend it to all practical men who have had experience of submitting street lighting schemes to local authorities.

For a standard specification to serve the important end of providing a local authority with a basis for the invitation of tenders, it is absolutely essential that it should leave nothing vital to the discretion of the contractor or the choice of the authority after the tenders had been opened. All questions involving choice—questions of height and design of column and so forth—must be decided beforehand, and the result embodied in the invitation to tender. I believe that every surveyor will agree with me on that point, and I consider that the failure of the draft specification to provide for that essential is absolutely fatal to its acceptance as a model.

6. Finally, the provisions under which the testing shall be carried out to determine whether or not the contractor is fulfilling his obligations must leave as little room for error, dispute, and injustice as possible.

It is generally admitted that anything approaching absolute accuracy in reading small minimum horizontal illuminations is impossible. Even in the case of fairly high values we find variations of 7 per cent as between readings by the same expert photometrist, Prof. Morris, and no one closely acquainted with street lighting photometry would be willing to accept a margin of less than 25 per cent to provide against errors of observation and local disturbing influences in taking low minimum illumination readings.

It will be said: take your readings direct from the various lamps contributing to the minimum illumination, and calculate your minimum illumination from them. But this method introduces, as the Committee have seen, a possibility of over 20 per cent difference, apart from errors of observation.

Will surveyors—or councils—allow a margin of 33 per cent from the contract minimum, or are contractors to be obliged to provide that excess in order to guard against possible penalties? And is a specification that necessitates the one or the other of these alternatives a scientific or a practical proposition to put before street lighting authorities? Here, again, let me quote Dr. Louis Bell:—

"If illumination is to be the real basis of a contract, penalties under that contract must depend upon a measured deficit in illumination, and practically all photometrists in this country who have had experience with illumination measurements on the street recognize that the degree of obtainable precision is not sufficient to justify making them the basis of large monetary settlements. In a street lighting contract involving £50,000 or £100,000 per year, a difference of 2 or 3 or 5 per cent in the measured illumination is a very serious matter, and dependence upon

measurements which are known to vary within at least this range would simply lead to exasperating litigation. I have made a very large number of measurements on the street, first and last, in a considerable variety of instances, and know from personal experience the magnitude of the difficulty here referred to, and the utter hopelessness of getting an amicable agreement between the municipality and the contractor on any such uncertain basis."

I submit, then, that this draft specification fails in every essential point to meet the requirements of a standard specification for street lighting.

That is, however, only destructive criticism. What practical alternative is there to offer? I am of opinion that if the Joint Committee would abandon the proposed "Unit of Measurement" Clause, and substitute one providing for rated candle-power of lamps determined by direct readings at specified angles in a specified direction, with a specified relationship between readings at the widest and the narrowest angles, and would provide a schedule showing by what number and arrangement, height, spacing, and placing of lamps of specified candle-power the illumination of streets in Classes A to E (or F or G) could be (because it has been) obtained, they would produce, and very quickly produce, a specification of real practical value with a truly scientific basis—and in this opinion I am again fortified by Dr. Bell, who considers that the draft specification would be improved "if more stress were laid upon the candle-power at a fixed angle from the lighting units to be furnished."

The draft specification suffers, if I may say so without offence, from science run mad; it has the atmosphere of the laboratory and not of the street, and I ask the Joint Committee to come down to practical conditions and considerations, and leave so-called scientific specifications to those who find them all-sufficient.

I only want to say in conclusion that the criticisms I have felt it my duty to make have been directed solely to the end of securing a satisfactory standard specification for street lighting. Such a specification is badly needed, and a practical, equitable, comprehensible, and comprehensive specification will be welcomed by all suppliers as well as all users of illumination. But it would be worse than doing nothing to meet that requirement to put forward an impractical specification, applicable at best to only one case in ten, that would not hold water in even the one case, and that would leave the local authorities in the same condition of uncertainty as to what they want and how to get it as they are in at present.

Professor J. T. Morris thought it would assist matters if he were to try to clear up the question of certain measurements of his which had been called in question. Mr. Patchell, at the previous meeting, had kindly referred to certain tests which he (the speaker) made as a member of the Street Lighting Specification Committee. He had felt it his duty to place before that committee absolutely every measurement which he had made; but the discrepancies referred to were obtained at only very low illuminations. He had not repeated the tests in question, because he had not the time, but in any thorough work he would naturally have repeated the tests. He had since collected the figures that were obtained, to see if there was any reason for the discrepancies; because not a few speakers had referred to the fact that there was an error of something like 22 per cent between the calculated horizontal illumination and the actual measured value on the same plane. Starting with an average illumination of 0·030, he got an error of 3 per cent; at 0·25 foot-candle he got exact coincidence. Then with a horizontal illumination of 0·021 there was an error of 7 per cent; and it was not until he got below 1-50th foot-candle that errors of 10 per cent crept in. The 22 per cent was obtained when the illumination was 0·017 foot-candle. Taking, instead of percentage error, the actual difference in amount of illumination, the figures gave 1-1000th foot-candle in the first case, zero difference

in the second, $1\frac{1}{2}$-1000th foot-candle in the next case, and it was not until the illumination was as low as 0·017 foot-candle that he got 4-1000th of a foot-candle difference. These figures seemed to show that the lower the horizontal illumination to be measured, the greater was the actual difference between the measured and the horizontal, so that the percentages went up at a very much greater rate. He desired, however, to emphasize the point that, provided the illumination was not below 0·020 foot-candle, the observed discrepancies were not more than about 0·001 foot-candle. Personally, he would have been glad if these figures had not been put before the technical public; because they were just a statement of actual observations made without any check tests, and it must be remembered that they were made over two years ago. He believed that, with the improvements of present-day photometers, these figures could be easily improved in the matter of accuracy. The Honorary Secretary kindly sent him a number of criticisms from engineers on the Continent and America, and frankly he must admit that the experience of these well-known men seemed to go against taking minimum horizontal illumination as the sole basis. Some agreed with it, provided something else was taken into consideration; and he did not know whether it was possible to arrange for a minimum horizontal illumination *plus* either the average or the mean spherical candle-power given by the lamps. This was a mere suggestion, but in view of the opposition he thought it was clear that some modification was required. In making it, however, he did so quite personally, and because he was sure that the desire of everybody was to get a satisfactory solution.

A communication from Mr. J. W. Bradley, M. Inst. C.E., was then presented by the Hon. Assistant Secretary, as follows:—Speaking as one who has for many years had the specification and control of public lighting installations, who has for twelve years conducted the execution of contracts for public lighting definitely based on a candle-power standard, and has also, with his assistants, carried out comparative tests of surface illumination values, the writer does not hesitate to express satisfaction with the working of candle-power standard contracts, and a preference for that system.

To give an intending contractor the candle-power he is required to supply and the height above the street at which it is to be fixed (stating within limits the polar distribution), reserving the right of approval of the general character of the lantern and its reflectors, supplies the contractor with a definite practical problem to solve; and he can deal with it with much less trouble than if he is to consider the many points involved by the adoption of a minimum illumination value over a large area.

Consideration of these points, even if undertaken by him, would in many cases be largely wasted, because of the numerous questions which would crop up in connexion with the actual position of lamp-standards and the different intensities of light required throughout varying depths of atmosphere in town streets of different importance in many respects. It is also essential that if there is a weak spot in a lighting installation, that weak spot should be localized and improved up to standard from time to time as weaknesses develope, rather than that the contractor should be told that a certain area is not properly illuminated, and he should then have to set out to discover and remedy the fault.

If a contractor has to be penalized for a failure to supply a specified amount of light, he ought to be told of the exact point at fault, so that he may remedy it immediately. Moreover, it would probably be difficult to penalize a contractor for insufficient lighting, because the minimum illumination had fallen below a specified figure, when that temporarily depreciated light might be caused by changing circumstances entirely outside his control, such as a change in the weather, the non-painting of a house front, the growth of trees, &c.

Again, if a contract is on a surface illumination basis, how is provision

to be made for a change in lighting unit ?

The writer cannot agree with Sir William Preece when he says "that it does not concern the public whether light is produced by a few lamps of large candle-power or by more lamps of less candle-power, or whether tall or shorter posts are used." It is certainly very desirable that as few lamp-posts as possible should be used, considering the obstruction they cause to the public ; and it is also desirable in important streets that tall lamps giving a proper illumination throughout a sufficient depth (vertical height) above the street surface should be adopted.

It is wrong to assume that the positions of the points of light and their number can be omitted with advantage from a contract. The approximate number ought to be definitely stated, and a price given in the tender per position for each class of lamp. The positions in which they are placed must be a matter entirely in the hands of the municipal engineer as representing the local authority. There are many things to be taken into account which a contractor forming his tender on an illuminated surface basis could not anticipate and allow for, and which prevent that equal distribution of light over the illuminated surface and through the illuminated depth which is so desirable, but impossible to obtain under working conditions, and which those who advise the adoption of illuminated surface as a standard have not and cannot provide for.

The position of vaults, cellars, areas, and forecourts, the presence or absence of gas, water, electric, telephone, telegraph, hydraulic, and other mains, tables, and services in the street or footway, have a large bearing on the position in which a lamp shall be placed. The angles and junctions of streets, recesses, and projections of buildings ; the distance of the building line from the street line ; the character of the dwellings and of the rooms adjacent to the proposed lamp position, and the use to which the rooms may be put near a lamp position, have all to be considered. The trade carried on in a shop adjoining may also frequently be influenced by the presence of a lamp ; and to suggest that it should be left entirely to the contractor to put his lamps where he will, so long as he illuminates to a satisfactory degree a plane at a height of 3 ft. 3 in. above the street level, is unreasonable, and would lead to endless disputes between ratepayers and the local authority, and the contractor and the local authority.

This matter cannot be looked at from a laboratory standpoint, but must be considered in the light of the hundred and one practical points which arise in actual working, and with due consideration to the class and amount of traffic, pedestrian and vehicular, on roads varying in character from the village highway to the metropolitan street.

The writer believes that he was the first to specify in a lighting contract a definite amount of measured light as a basis for tendering, and after many years' experience of public street illumination, carried out under contracts having for their basis of agreement the measurement of direct candle-power, and with the knowledge of the working of such contracts in respect of both gas and electricity, intensified, filament, and arc lighting, he can definitely state that these contracts have proved satisfactory in every way ; further, they have lapsed and been again re-entered upon by the previous contracting parties—a fact which in itself testifies to their fairness and ease of working.

The principal points of this specification are indicated in the following extracts :—

The Contractor shall pay to the Local Authority as liquidated damages the sum of 5*s.* per day or portion thereof for every lamp giving at the time of testing less than the specified candle-power provided for in the annexed specification, each day commencing at twelve o'clock midnight. Tests may be made at any time during the specified lighting hours.

In the case of "large units," the lamps are to be erected on suitable and approved columns of such a height that the centre of light shall not be less than 22 feet above the adjacent surface of the ground. In the case of "small units," the centre of light shall be not less than 12 feet from the adjacent ground surface.

The design of lamp-pillars is subject to the approval of the Council, and such pillars must

be of cast iron or cast iron and steel tube construction. In the case of electric lamps, provision must be made for the winding gear to the footway columns. Arc lamps shall be fitted with automatic substitutional resistances, so that the failure of one lamp will not interfere with others in the same group.

Each lamp is to be fitted with burners, mantles, globes, and fittings, as the case may be, giving a minimum of 90, 180, 1,800, or 3,000 standard candle-power respectively, as directly measured by an approved portable photometric apparatus placed at ground-level, and is to burn 3,940 hours per annum in accordance with a daily schedule to be hereafter supplied by the Local Authority. The fittings and lamp must be in every respect to the approval of the City Engineer, and in particular the reflectors above the light are not to be concave to the light so as to concentrate the illumination at the foot of the lamps, but horizontally flat or slightly convex as approved by the City Engineer, so as to disperse the rays. The tests will be taken in such a manner as to ensure that glazing bars shall not interfere with the results obtained. The candle-power shall be arrived at by taking the average of two readings in any position with regard to the light under test—one reading at an angle of 20°, and a second reading at an angle of 50° to the horizontal. A test standard unit of 1 foot-candle or of any size in excess of this up to 10 foot-candles may be used, according to the character of the photometer with which the tests are made and the class of lamp being tested, all as the City Engineer may approve. The photometer shall be of a type approved by the City Engineer The intention of this contract is that the Contractor shall assure himself, by continued test and inspection, that the lamps he provides are during lighting hours fulfilling in all respects the requirements of this contract, and he shall not claim relief from the conditions of this contract on the grounds of non-notification on the part of the Local Authority of any failure to comply with the terms of this specification. The light given shall be of a steady, invariable character, of a white or yellowish-white colour.

Mr. J. Darch remarked that none of the advocates of minimum illumination suggested that the position of the lamps should not be mentioned. Surely a specification should state the position of the lamps and every point that was necessary to ensure the strength of the lamps being such as to produce a good illumination. He thought the discussion should be made upon these lines, and not upon the lines suggested by Mr. Bradley.

Mr. Frank Bailey said that most of the speakers in the discussion seemed to have ignored Appendix A of the specification, which he regarded as a very important part of that document. There were, he thought, several reasons for congratulation in the preparation of this specification. First, that the Illuminating Engineering Society had been selected as an impartial tribunal to discuss the subject, in the full knowledge that justice would be given to all concerned, whether they agreed or not; secondly, that this paper had been the means of drawing from Mr. Trotter one more practical paper on this subject, upon which he was a master; thirdly, that so far the criticisms on the specification, and the objections raised, were so easily answered. He could not do better than leave this to others, but he declared himself a whole hogger, and occupied the same pen as Mr. Edgcumbe. As one who was present at all the meetings of the Joint Committee, he could only say that the occasion was exceptional, for although a number of men having different views met together, the care and persistence with which they pursued these negotiations were most creditable to all concerned. Electrical engineers, perhaps, were in the majority, but the other Societies, and the gas engineers in particular, sent very representative members, and during the whole proceedings, no matter how divergent the views, and how much they disliked the specification, they not only expressed their views clearly, but they treated the rest of the Committee with the greatest courtesy.

Therefore he looked forward to the time when electrical engineers would have the pleasure of meeting them again, when perhaps they would have assimilated some of the specification and had time to study Appendix A. Then, perhaps, it would be possible to get a workmanlike specification which would be satisfactory and acceptable to all parties. So far as the surveyors were concerned, there, again, the Committee met with every assistance, and it was astonishing that men, having such large responsibilities, should be able to find the time to study a comparatively new subject, and were able to give such practical assistance; so much so that the surveyors redrafted many clauses in Appendix A, and he believed they were more proud of them than he was personally. He now came to a matter which he regretted very much, and that was that an

attempt had been made by Mr. Abady at the last Annual Meeting of the Institution of Gas Engineers to prejudice the specification before it came up for consideration at the joint meeting with the Illuminating Engineers and the other societies. At that time the document was a confidential one, and to have discussed it in the hostile spirit that Mr. Abady did was not the right thing.

Mr. E. Allen, as Vice-President of the Institution of Gas Engineers, expressed his appreciation of the valuable work done by the Joint Committee, which, he said, was bound to be an advantage to the general public. In his town the Corporation did the whole of the lighting, and there was one street, where there were centrally suspended lamps at a great height, in which the lighting was less satisfactory than in any other street in the city. He had no doubt that the minimum horizontal illumination was good, but when one was walking up a street one did not wish to be reading a paper. One rather wanted to see the man coming towards one, and either to avoid him or recognize him, and the general effect of the lighting in that particular narrow street was most unsatisfactory. The Committee, of course, desired to produce a specification suitable for all undertakings in the country, and it appeared to him that it would be wise if the Committee gave further consideration to the matter. He was quite satisfied in his own mind, and was strengthened in this opinion by Prof. Morris's remarks, that there was good reason for consideration on the part of the Committee as to whether, in addition to the minimum horizontal illumination, it would not be a wise thing to fix other considerations in the proposed standard specification.

The Chairman mentioned that he had called upon Mr. Allen after what Mr. Bailey had said because he thought that, as Vice-President of the Institution of Gas Engineers, he might desire to make some comment upon what Mr. Bailey had said with regard to Mr. Abady's remarks at the Institution of Gas Engineers' meeting. It was only fair to Mr. Abady to say, on behalf of the Council of the Institution of Gas Engineers, that the discussion at which he spoke was a discussion invited by the Council, without, certainly, any knowledge in their minds that they were in any way committing any breach of confidence in instituting a discussion upon the specification after it had been referred to them for consideration. Mr. Abady was specially invited by the Institution to express his views on the matter, and any responsibility for his having done so rested, not with him, but with the Institution of Gas Engineers. He thought it was only fair to Mr. Abady that this explanation should be made.

Mr. Allen said he quite agreed with what the Chairman had said.

Mr. Roger T. Smith (Great Western Railway) hoped that a few observations on the specification as a result of some experience in lighting railway stations and yards might not be considered irrelevant.

There seemed to him in general to be two ways in which a specification could be drawn. First, the method usually adopted by architects and constructional engineers, in which every detail of the work required was specified, leaving the contractor to carry out these details, so that the man who drew the specification is entirely responsible for the results. Then, secondly, there was quite a different way of drawing up a specification, largely used by those who specified machinery, which simply asked for a result, leaving the entire responsibility for the way in which that result was achieved with the contractor. Between these two opposite methods there were certain variations combining something from both, but the thing which seemed to be a violation of all the proper canons upon which a specification should be framed was that complete details should be specified, and at the same time the contractor made responsible for the result for which he had already really ceased to be responsible. The Committee had fol-

lowed the machinery method in that they had simply asked for a result and allowed the contractor to obtain that result, not quite by any means he chose, but by means limited by clauses 7 and 8.

It seemed to him that much of the criticism the specification had received was due to the fact that only a result was asked for. This view seemed specially taken by the representatives of the Institution of Gas Engineers, who apparently were not prepared to trust the contractor to get the results asked for in the best possible way, and they were especially doubtful whether contractors using different illuminants would use the best means of arriving at the same result, when that result is minimum horizontal illumination. For the past seven years he had designed all the lighting of his railway stations and yards on the principle of minimum horizontal illumination measured 4 ft. from the ground, but in future it should be measured at a height of 1 metre. One speaker had said that horizontal illumination measurement did not seem fair to the light, because the actual values were so much less than if the direct ray was measured or the component on a vertical plane, while quantities like variation factor were different. Now what the Committee had been trying to do was to save people's time. Mr. Trotter had shown years ago, and all experimenters agreed, that if they measured the vertical component of illumination on a horizontal plane, the horizontal component measured on a vertical plane was always greater, except just under the lamp, and of course the resultant of the two components was also greater than either of them. Surely, if they could settle on what was only a pure convention—minimum illumination on a horizontal plane, one metre from the ground—if they could possibly agree to use this one measurement from which all the other values could be calculated, it did not matter at all whether what they really wanted was illumination on the ground, or on a vertical or inclined plane, for all these quantities were greater than the horizontal minimum. For a railway engineer who had to deal with 3,000 miles of line, and who had two assistants who could occasionally be spared for photometric work, time was absolutely essential. It would be impossible for him to undertake photometric illumination work at all unless it could be done quickly, and although those responsible for street lighting might be more fortunate, time was very important to them, and if one measurement could be settled on, to be upon one plane quite arbitrarily chosen as the most convenient for measurement, but the only plane which received illumination from every possible source it would be a great gain for scientific lighting.

A moment's consideration showed that the horizontal plane was the only plane on which by one measurement such a result could be achieved. In a railway station in the midlands, where experimental lighting was in progress, 30 per cent of the minimum horizontal illumination of one platform was received from lamps 35 ft. away on the other platform. That was an extreme case, but at Paddington station the lamps on No. 1 departure platform supplied 16 per cent of the minimum illumination on the opposite platform 48 ft. away. If it was possible to include all this illumination by one measurement on a horizontal plane instead of by certainly four, and probably six measurements on other planes, and a lot of arithmetic, and to do it in one-tenth of the time, surely it was possible to carry out ever so much more in the way of measurement than was possible if the work was done in a more roundabout way. If only one result was asked for in the specification, that one result could only be horizontal illumination and nothing else, and the contractor was perfectly justified in including in his result all the illumination that he could get from other sources of light or from reflection. On the whole, he thought the principle of the specification, in asking for minimum horizontal illumination only, was right, but for railway purposes clauses 7 and 8 of the specification would have to be amplified a little. The variation factor had already been referred to, and for railway work at least, and possibly for street lighting also, the variation factor ought

to be mentioned. Perhaps the most convenient way in which to include it was to specify a certain horizontal minimum illumination, and also a horizontal maximum illumination, the latter of which should be stated within plus or minus limits. Less conveniently it might be specified that the maximum horizontal illumination near to the lamp should not be less than a certain value, and should not be greater than a certain value. Perhaps if the Committee had amplified clause 8 a little, and added a model schedule, showing the sort of information the contractor had to give, opponents of the specification would have realized what complete control the specification gave.

With regard to glare, he would suggest an addition to the specification, namely, to specify maximum intrinsic brilliancy of the illuminating source. There was a great deal of very much advertized lighting in the streets of London which to his mind was a perfect disgrace, owing to the intense glare from the lamps. As had been pointed out by one speaker, people's eyes were so dazzled, and the pupil so contracted by the effect of glare from intensely bright lamps, that the minimum illumination midway between the lamps was hardly able to enter the eye at all. He thoroughly and entirely believed in the specification as it stood, and intended to work to it himself, but for his own purposes he should always elaborate clause 8, as well as add a term for variation factor, and also limit the intrinsic brilliancy of the lamp.

Mr. W. R. Cooper first objected to the expression "diversity factor" as applied to street lighting, as it was already commonly used in another connexion, and would only result in confusion. He therefore strongly urged the expression "variation factor," which had already been used in street lighting.

The objections which had been made to horizontal minimum illumination were largely due to misconceptions. The only serious point for consideration was whether it was possible to measure the quantity sufficiently accurately for penalty purposes. It was quite rational to adopt horizontal illumination as a criterion in preference to vertical illumination, because the horizontal component reaches its limit of usefulness before the vertical component. Some speakers had objected to the use of horizontal illumination, because it could only be applied directly to 80 per cent of the streets. He did not think this was a serious objection. In a great many streets only "beacons" could be used for lighting, and their candle-power could be taken as the means of measurement; it gave a perfectly definite result. But the higher the illumination the more difficult it was to interpret the meaning of candle-power, and the more easy was it to measure illumination. The Chairman had remarked that it was essential that the basis of the specification should be understood by the town councillor, but perhaps he (the speaker) would be excused for taking the view that it would be quite sufficient to mention the class of street for the purpose of the town councillor, and leave the measurement and the understanding of details to the engineer.

If they did not take the minimum horizontal illumination what was the alternative? Personally, he was not very clear from the remarks at the last meeting what the alternatives were. A good deal had been said about normal ray illumination. Of course, that was higher, and it seemed to be the idea that it would lead to more definite and more easily found results. That was not necessarily so.

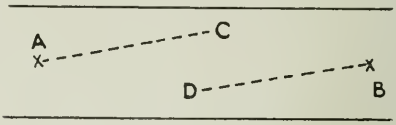


Fig. 1.

Fig. 1 was a simple diagram showing how it was impossible to get a definite result unless the candle-power was the same in all directions in what astronomers called azimuth. In the diagram, which represented a street in plan, A and B were lamps having minima along rays A C and B D and the minimum horizontal illumination would not be either at D or C, and

in this case it would not be a simple matter to find the minimum by direct ray measurements. Some speakers were inclined to go in for candle-power, but he did not think the difficulty of this method was appreciated as it should be. With high illumination candle-power was apt to become indefinite, and errors might possibly creep in from neighbouring lamps. Further, what, for example, was the candle-power of a dioptric globe? True candle-power should be the same along the whole length of the ray, but it might be found that they were not getting different candle-powers at different points along the same ray, in which case the measurements were valueless. Also, what was the result with reflectors, and supposing one was dealing with groups? Fig. 2 showed

FIG. 2.—Showing cluster of lamps on one standard on the "Great White Way" method.

the street standards similar to those used on the "Great White Way" in Newhaven, U.S.A. What would be meant by the candle-power on the 50° ray in such a case? One extremely great advantage of minimum or horizontal illumination was that it took account of every source of light, and might be applied to every type of lamp for illumination, past, present, and future.

Mr. Roger Smith had referred to glare, and he (the speaker) also did not feel quite happy about that subject. It was not referred to in the specification, although Mr. Trotter had mentioned it in his paper. According to the specification, one might take a street in Class A and raise it to Class E by increasing the candle-power ten times without raising the lamps. One might equally double the height of the lamps and use a lower candle-power. Would the result be the same? He did not think so. He thought it would be much more unsatisfactory with ten times the candle-power, and therefore this should be taken into account in some way. Much depended on the intrinsic brilliancy of the source; a great deal also depended on the variation factor, and that rendered the whole question rather difficult. The intrinsic brilliancy of the source might be decreased considerably in the future, and therefore it was a little difficult to specify merely a certain variation factor.

Another point was the question of the plane on which the illumination was measured. Various planes had been suggested—3 ft., 3 ft. 3 in., 4 ft., 5 ft., and 1 metre. The reason for selecting 3 ft. 3 in. in the specification was merely that this was a convenient height for measurement, and was nearly 1 metre. Nevertheless, in every-day use the pedestrian used the horizontal illumination on the street surface, not one metre above it. Personally, he used the horizontal illumination on the street surface more than the vertical component. When driving a motor-car, for instance, one looked at the road surface. There seemed to be some confusion in people's minds as to horizontal illumination and vertical illumination. They seemed to think that it was necessary to have the horizontal illumination at 3 ft. 3 in. in order to see one's watch, or recognize one's friends, but for such purposes the vertical illumination was really used, not the horizontal. There seemed no sound reason for measuring horizontal illumination at a height of one metre when it was required at the street surface. Because it had been so measured in the past was no reason why it should continue to be so measured. Moreover, it was unscientific and introduced

a variable error. As to whether this error was serious from the point of view of measurement depended upon the height of the posts and distance apart. Mr. Trotter stated that the error was inappreciable at distances beyond one and a half times the height of the lamp posts away from the lamp. That was only partially true. Mr. Trotter also stated in his book on illumination that the error was negligible if the posts were not less than 18 ft. in height. They might, however, have to deal with lower posts, and as the error increased as the height was diminished the lower posts would be penalized. Taking an actual case of lamps at heights of 20 ft. and 12 ft. respectively with posts 100 ft. apart the following results were obtained :—

20 ft. poles (*i.e.*, to source of light.)

3 ft. 3 in. plane reduces minimum horizontal illumination by 10 per cent.

3 ft. 3 in. plane increases variation factor by 57½ per cent.

12 ft. poles (*i.e.* to source of light.)

3 ft. 3 in. plane reduces minimum horizontal illumination by 25 per cent.

3 ft. 3 in. plane increases variation factor by 154 per cent.

These figures showed how unfair the use of such a plane could be in making comparisons. The question was not merely one of academic interest, because the use of low posts seemed to be on the increase. If glare was avoided, as in the Great White Way lamps (of which one example might be seen outside the showrooms of the Brompton and Kensington Co., near Earl's Court Station), there was no objection to low posts. He therefore hoped that the Committee would not adopt a system which was not only unscientific but led to false comparisons. No basis should be adopted which might place future systems at a disadvantage.

Mr. Jacques Abady in the course of his criticism of the specification, first of all thanked the Council of the Society for the opportunity afforded him as a visitor of voicing his views as to what, to him, was a very important subject. He would open his remarks by referring to a phrase which occurred in Mr. Trotter's paper. After saying that there had been various suggested forms of specification discussed, and that the Institution of Gas Engineers objected to the fundamental basis of the specification, the author went on to remark : "The Joint Committee, in these circumstances, were reluctant to take any further steps until an attempt had been made to review the problem, and to give an opportunity for a full debate upon it." It was because the Joint Committee had done this that he was able to be there that evening, and that those present were able to listen to the very interesting remarks that had fallen from the lips of those who had already spoken. But it really did strike him as being somewhat extraordinary—if he might venture to say so with very great respect and with a certain amount of egotism—that, if it had not been for his lamentable outburst at the Institution of Gas Engineers, the specification which had found a good deal of tacit acceptance or acquiescence for want of any considered opposition might now, he believed, have been a *fait accompli*. It seemed to him to be an extraordinary proceeding to have drafted a specification, and bring it apparently down to the point of accepting it (if his view was correct), and then afterwards to hold a meeting in order to "review the problem." He was relieved to find that Mr. Trotter's paper was simply a summary of the deliberations and findings of the Committee, because he was well aware that he had expressed himself as strongly adverse to the specification. But, as the matter was put impersonally, it relieved him of the responsibility of having to deny any charge that he had been guilty of any disrespect to the learning or experience of any individual member of the Committee. And, speaking again personally, might he say that no one in the room shared more than he did admiration for Mr. Trotter, and the great amount of useful work he had done on the subject of illumination.

But he could not lose sight of the fact that it was twenty-four years

since he (Mr. Abady) first did photometrical work, and some twenty years since he designed his first photometer; and from the aspect purely of years of constant testing and experience he did claim the right to make his voice heard in no uncertain way, without being accused of being dogmatic or conceited in giving expression to his views as he did at the meeting of the Institution of Gas Engineers, and as he intended to do that night. He admitted that the phrase he then used, and which had been quoted, was not worded in the way he should have worded it had he known he was to be invited to attend the present meeting. (Laughter.) But still it was more a question of manners and phraseology than anything else. There were two ways of describing one's views. Mr. Winston Churchill, for instance, called a lie a "terminological inexactitude"; but he was not at all certain that the direct way was not the right and the best way after all. He might, perhaps, have put his views in a more polite manner; but honestly he could not go back from the opinion his words were intended to convey—viz., that this specification was absolutely and completely wrong from beginning to end.

Mr. Roger T. Smith had said there were two ways of drawing a specification. There were—the right way and the wrong way. And this was the wrong way. The specification was completely wrong from beginning to end. When he got hold of it and read it through, and learned that the Society of Illuminating Engineers were going to discuss it, he rubbed his eyes, and wondered whether he was dreaming. The specification was far removed from anything that was likely to be of any service to any individual, and it was amazing that they were actually called upon to discuss it seriously. It was only right that he should give the reasons as to why he held these views. The first was this: The specification purported to deal with contracts for street lighting—with contracts made between a supplier on the one hand, and a council on the other. It set up a certain standard minimum illumination, measured in a particular way, measured in two ways—in two alternative ways if they liked. It admitted *ab initio* that 80 per cent of the lighting of the country could not be measured under the terms of the specification. Was that a correct statement, or an incorrect one? Either it was right or it was not. Either one could measure 80 per cent of the street lighting in the way prescribed in the specification or one could not. He said that it could not be done, and it was admitted by Mr. Trotter that it could not be done. Certain measurements and calculations could be made, and certain results produced. This was not the same thing; and it was his view and experience that the theoretical ascertainable horizontal illumination deduced from the sum of different illuminations did not agree with the horizontal illumination that was obtained by a single direct measurement. And he thought that Prof. Morris's explanation—he (Mr. Abady) would rather call it an excuse—was welcome testimony on this point.

The next thing was that the specification prescribed mimimum illumination. Before, however, he went any further, he might deal with the point one speaker made—that although the specification set up a standard of minimum horizontal illumination, yet the position, heights, and distances apart of the lamp-posts had also to be given by the tenderer or contractor. What he (Mr. Abady) suggested was that, if they had two lamps, 10 feet high, 100 ft. apart, and a 100 candle-power lamp on each and giving x foot-candles, the utility of these lamps arose because they were 10 ft. high, 100 ft. apart, and had 100 candle-power lamps upon them, and not because they happened to give a certain theoretical horizontal illumination 3 ft. 3 in. above the road level. They could not divorce the one from the other. If there was any virtue in the lamp on the post, it was because it was a lamp on a post, and not because the lamp on the post gave an illumination reading made in a particular way. It followed that obviously the proper way was to measure the candle-power of the lamps, the positions and heights

of which had to be specified. The point was, as he had said, that the specification prescribed minimum illumination. Now he had been taught that before one could cook a hare it was necessary to catch it. The term minimum connoted a search for the minimum; and if it connoted a search for the minimum, it left a great deal to the discretion of the person making the test. He suggested that if one wanted to find the minimum one had to explore the streets, so as to know that one had got the minimum. He made this point with all seriousness. He would even sweep aside any want of *bona fides* on the part of a local authority—who wanted to penalize the supplier. In order to find the minimum one would have to search for it; and that involved making tests other than the minimum. If this was true, then surely it meant that they could not go about the thing in the simple sort of way suggested by merely taking a "cigar box" photometer from one's pocket, making a test, and then saying that is the minimum. One could not get the minimum without some means of definitely knowing whether or not it was the minimum. The argument urged in favour of the minimum horizontal —viz., that it was so simple and could be done instantly—therefore fell to the ground. The next point was the horizontal illumination. If the minimum was a matter which did not afferd any basis of comparison between one street and another, then with how much greater force did he same contention apply to the minimum horizontal illumination. It was said "quos Deus vult perdere, prius dementat"; and whatever possessed the Committee in putting Mr. Haydn Harrison's table at the end of their specification, as evidence of the comparison of horizontal illumination, he could not imagine. If the minimum horizontal illumination was a proper test of the comparison of the lighting in one street, and if in another street it was the comparison of the lighting of a street in terms of itself, or of any standard, then the table had a bearing on the accuracy or otherwise of this as a comparison, because it was the basis on which 80 per cent of the illumination of the streets was to be arrived at. He did not know that he could make this table look more absurd than had been done already, but he would try.

If they took lamps spaced 100 ft. apart, with posts 10 ft. high, the table said they required lamps of 95·5 candle-power in order that the sum of two lamps should give a minimum horizontal illumination of 0·01 foot-candle. Suppose a badly lighted street—lighted he would say by gas, and not by electricty, as he wanted to be impartial, and because the Chairman was avowedly a gas man—supposing it was lighted by flat-flamed gas-burners (he did not know that there were many streets in existence that were so lighted), supposing then that somebody who was interested in the conversion of gas-lamps to electric lamps came along and saw these posts 10 ft. high and 100 ft. apart, and said to the local council: "I see that you have flat-flame burners consuming 6 or 8 ft. of gas, I can supply you with 100 watt lamps which will give you 95·5 candles." He (Mr. Abady) was assuming for the moment that there was such a thing as a "one-watt" lamp. The gas man (who was not always such a fool as he looked), would turn up this illuminating engineer's specification, and he would find to his joy that if he doubled the height of his post, and put on incandescent gas-burners, using two cubic feet of gas an hour, he could easily get 43·8 candles. According to the table, the lighting would be precisely the same. Would that be fair to the man who wanted to light the streets by electricity? He (Mr. Abady) would ask any man in the room to say whether, as a matter of actual fact, whether as a matter of practical utility, lights of 43·8 candles on 20 ft. posts, 100 ft. apart, would give the same illumination as lights of 95·5 candles on 10 ft. posts the same distance apart. Was it not an absurdity? He asked the Committee why not, without further ado, take the whole thing back and reconsider it?

Look at the table from another point of view. Supposing they were going to alter the distance apart of the lamps; supposing they were 100 ft. apart, and 10 ft. high, and were giving a light of 95·5 candles, they had only to move them 10 yards (30 ft.) further apart, and the table said that they would have to more than double the illuminating power in order to give the same illumination. Was not that ridiculous? If people would only thresh out the table, they would see what an absurdity the basis of comparison was, and that minimum horizontal illumination as a basis was altogether absurd. He could not say more.

He was glad to hear Mr. Cooper confirm his condemnation of horizontal minimum illumination; and he did so quite from another point of view—that was to say, to make a horizontal test 3 ft. 3 in. from the ground did not set up a proper degree of comparison between high and low posts. He (Mr. Abady) emphasized this point at the celebrated meeting at the Institution of Gas Engineers, when he took leave of his senses and manners. (Laughter). And now he was confirmed months afterwards by Mr. Cooper, who represented an entirely different interest. While the basis of the specification might all be true theory, it was theory run mad.

Horizontal illumination never was, never could be, and never would be a true comparison between one system of lighting and another. He said with every confidence—he was rather an unassuming man with a fair amount of self-confidence (Laughter)—that they could not dissociate the lighting effect, first from the source, and secondly from what was being illuminated. They could not dissociate illumination from the source nor from the surface which received it. They saw everything not by the light which fell upon it, but by the reflection from it. They did not see anything in any other way but by reflection. On this point again, and without any collusion, Mr. Cooper came to his rescue. Mr. Cooper said that the horizontal illumination that they wanted was the horizontal illumination on the street surface. Precisely. If this was so, then was not the value of this illumination dependent upon the nature and condition of the surface and the position of the source from which the light fell? The reason 3 ft. 3 in. was chosen was because it was possibly a convenient height. It meant nothing; it was nothing. They did not have horizontal illumination 3 ft. 3 in. high. The apparatus used for lighting the streets was not for the purpose of illuminating anything 3 ft. 3 in. high.

Having made these remarks, he did urge that he should be taken seriously, and not be considered discourteous because he was expressing himself with great emphasis. Mr. Cooper had made some interesting points as to the possible difficulty of measuring the illuminating power of lights fitted with dioptric globes, and had referred to the same difficulty with groups of lamps such as were used in what was known by their American friends as the "Great White Way." That difficulty could be got over by simply specifying and reading in "foot-candles on the normal at certain specified angles," just as in the Westminster specification, but omitting the calculation to convert this reading into candle-power of the source. It amounted to exactly the same thing.

He was in favour of the Westminster specification, with which he had something to do when he was Chairman of the Lighting Commitee of that Corporation, because what they got on the photometer in the street was a true reading representing so many candles. It would be exactly the same thing as he had just said, if they specified posts so many feet high, so many feet apart, and producing normal illumination of so many foot-candles at an angle of so many degrees. In the paper, Mr. Trotter asked what were the local authorities out to buy, and answered his own question by saying, "not lamps, not candle-power, but illumination." If Mr. Trotter could phrase his sentence in this way—"What are they out to buy? not lamps, not candle-power, but minimum horizontal illumination"—

then he (Mr. Abady) would say there was some justification for the paper. He challenged Mr. Trotter to add these words. But he knew he could not, because, though the specification dealt with minimum horizontal illumination, Mr. Trotter knew very well that that was not what they were out to buy. The specification of the illumination left out of consideration everything else—such as glare, &c. It was evident from the sign given by the Chairman that he had come to the end of his time. But he must remark that the specification and paper simply bristled with inconsistencies. In one place it said an error, under normal circumstances, of 1 degree of angle of inclination of the photometer made an error of 10 per cent. Yet the specification said a photometer would be considered suitable if they could measure angles to 2 degrees! Therefore, they could get 20 per cent error from this source alone and still comply with the specification. Was not that another absurdity?

But whatever specification was adopted, if one were adopted, he should urge that Classes "A" to "E" should be revised. To put the point briefly, there was too much difference between the classes—that was to say the middle Class "C," for instance, had a minimum of 0·04 foot-candle; so that a street that had a minimum of 0·039 foot-candle would come into Class "B," the minimum for which was 0·025 foot-candle. There was thus a diversity of over 50 per cent in the same class. If they were going to ask a contractor to comply with the illumination under these clauses, then they were going to give him a margin of 50 per cent. He knew what the reply would be—that the contractor was going to work to a specific horizontal minimum illumination, and that what he gave over this did not matter. This did not, however, affect the looseness of the specification, which he (Mr. Abady) could not help condemning from every point of view and from beginning to end.

Mr. Leon Gaster congratulated Mr. Trotter on his paper—written and delivered with his inimitable charm and skill. At the same time he would like to give some account of the history of how the paper came to be written, as there seemed to have been some misapprehension on this point.

It would be recalled that the idea of a street-lighting specification dated from Mr. Haydn Harrison's paper before the Institution of Electrical Engineers in 1910. A suggestion made in the course of the discussion of this paper led the Illuminating Engineering Society to appoint a committee on this subject. Almost immediately afterwards an invitation was received for the Institution of Electrical Engineers to co-operate with that institution in forming a joint committee. The Illuminating Engineering Society gladly fell in with this suggestion, but desired that the draft specification, before being published, should be referred to the Illuminating Engineering Society for an open discussion on the points raised.

At the beginning of the present session it occurred to the Council that a paper on street lighting would be welcome to members of the Illuminating Engineering Society, and they very naturally approached Mr. Trotter, who had been so long identified with this subject. At Mr. Trotter's suggestion the paper was deferred till the end of the session, in the hope that the draft specification would be available, and permission granted to make use of all information brought before the committee. As a matter of fact, the trend of events led the various societies interested to regard this as a most favourable opportunity for presenting the specification in the rough form, so as to secure a public discussion on the impartial platform provided by the Illuminating Engineering Society. They would see, therefore, that from the very first the Society had kept this point in view, foreseeing that it was in a position to provide a common meeting-place, where the representatives of the various societies interested could meet and exchange views.

In conclusion, Mr. Gaster said that he did not propose to discuss the specification at that stage, but he would

like to remind those present that agreement on a general specification of this kind, applicable to all towns in the country, would be a great achievement. A specification that covered such a wide range must be *general*—not parochial. One should not, therefore, only look at the points to be criticized, but should also remember how much there was in the specification that was generally acceptable and beneficial, and endeavour to see how the conflicting points of view could be reconciled. If the Illuminating Engineering Society could but succeed in bringing about this agreement, it would have accomplished a magnificent piece of work.

Mr. F. W. Goodenough (*communicated*):—Mr. Trotter, in his reply at the meeting, laid great stress upon the fact, which he considered went far to prove the soundness of the specification, that the classification of streets made by the surveyors as the result of an inspection of their lighting by night was in agreement to a considerable extent with a classification of the same streets according to minimum horizontal illumination measurements—though there were, it should be noted, very material divergences in some instances.

There is no doubt, moreover, that the surveyors and their institution have been led to approve the draft specification, largely because of this same approximate agreement between the classification based upon the observation of their members and that based upon minimum illumination readings.

I should therefore like to point out the radical unsoundness of the argument, and to ask the surveyors to give careful consideration to the matter.

If the lighting of the streets which the surveyors inspected had been planned and carried out by contractors working to the specification as drafted, then it might well have been urged (though it still would not have been true) that lighting of a certain grade of value would always be produced in a street if a certain minimum horizontal illumination were specified. But that was not the case, and that is where the radical fallacy of the argument lies.

The lighting of the streets surveyed was designed and carried out on the usual plan of deciding, by experience and by experiment, what number of lamps of a certain description, placed on columns of a certain height, would give the kind of illumination that was desired or could be afforded in those streets.

The lamps on those posts at certain distances apart produced the illumination of the streets which the surveyors classified as A, B, C, or D, according to their impression of that illumination on inspecting the streets. But that effect, that optical impression, was produced by—what? By the following factors, in combination:—

The apparent brightness of the lamps.

The height of the lamps above the street.

The distance of the lamps apart.

The maximum illumination in the street.

The gradation of maximum down to minimum illumination in the street.

The minimum illumination in the street.

All these factors, not the last one only, go to make up the good, bad, or indifferent lighting of a street.

If in two streets you have about the same number of lamps of similar power on columns of similar height, you will get about the same maximum, average, and minimum horizontal illumination.

By a different number of lamps of different power on columns of different height, you can get the same minimum horizontal illumination, but a different maximum and a different average illumination—a differently lighted street altogether, such as no surveyor would class with the others.

Is it not then obviously illogical to say that, to ensure that a street shall be lighted up to a certain standard, it is only necessary to specify the minimum illumination which the contractor is to give, leaving it to him to give what maximum and average illumination he chooses?

I am quite sure that Mr. Trotter (and the surveyors) will, on further consideration of the matter, agree that minimum horizontal illumination is

not an adequate basis for either a specification or a contract.

Mr. N. W. Prangnell (*communicated*):—I do not wish to say much with regard to the controversy as to whether illumination or candle-power tests should be taken for the specification in question. What little experience I have had with maintaining street lighting under a specification including a candle-power clause has clearly shown that this is a most difficult and intricate method to employ, so many readings and calculations having to be made that the chances of errors are very materially multiplied.

To my mind there is no question that the simpler method is to take illumination tests. There are several quite good instruments now available for this purpose, from which one obtains direct readings, and thus can leave them to be taken by a man who need not necessarily be highly technical. I must add that I quite appreciate the difficulties in obtaining illumination tests with the poorer classes of lighting.

What I particularly wish to take this opportunity of doing is to follow Mr. Darch in his remarks on the question of glare. I am sorry that I cannot see in the suggested specification any clause that will restrict the objectionable glare obtained from so many of the modern light sources. I do not think that it should be left an open question as to whether a powerful light, giving its illumination from quite a small area should be placed at a height of either 12 ft. or 20 ft. I strongly advocate that a clause should be inserted in the specification which would provide that an illuminant giving its illumination from a given area of surface that is presented to the eye, should be placed at a given height above the ground. As an instance of my meaning, I would refer to Mr. Harrison's table on p. 16. It will be seen that to give an illumination of ·01 candle-feet with lamps placed 240 ft. apart, a 294 c.-p. lamp will have to be set 36 ft. high, but that if the height is reduced to 12 ft. the candle-power of the lamp would have

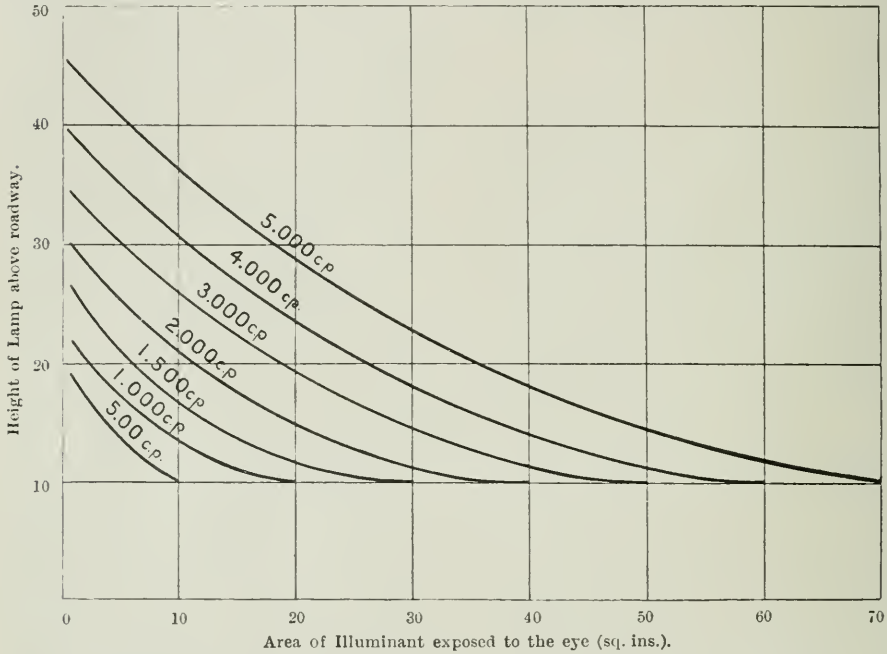


Fig. 1. Curve showing suggested heights at which illuminants of various candle-powers, and different areas exposed to the eye, should be placed with a view to avoiding glare.

to be 999. This latter, at first thought, seems ridiculous, but if you arranged that the 999 c.-p. lamp gave its illumination from a surface of 50 square inches, then it might be possible to place such a much larger light source at so small a height. By introducing this clause, it would follow that every new scheme would have to take this as its basis. It will also follow that the insertion of such a clause will not interfere with either of the methods under discussion of measuring the illuminant.

I feel so strongly on this question of glare that I would even suggest that this society should use its efforts to see if it would not be feasible to get this matter dealt with by an Act of Parliament, and thus make it a criminal offence to so place illuminants that the source of the light is injurious to sight.

Messrs. S. L. Pearce and H. A. Ratcliff (*communicated*) : — Whilst some general agreement on bases of comparison and method of measurement is eminently desirable, the difficulties encountered by the Committee have indicated the narrow limits within which such agreement appears possible. No two persons will probably ever agree regarding the best methods of illumination, and any attempt to obtain uniformity of method would destroy the variety which alone makes artificial illumination interesting.

We agree with the author that the purchasing authorities are out to buy illumination certainly. Illumination is what is required, and presumably what is sold. Candle-power figures in themselves are meaningless for two reasons : the absolute candle-power of a lamp is an undefinable quantity, and candle-power figures give absolutely no indication of the quality or extent of the lighting in a street unless used in conjunction with definite measurements of height and distance.

The quantity actually sold is the impressed illumination due to the light flux proceeding from the lamps, and it can only be determined accurately by means of candle-power measurements.

The author's statement at the bottom of column 1 and the top of column 2 on p. 4 appears to be reasonable, and provides ample scope for public opinion. Is it not, however, somewhat at variance with the author's contribution to the discussion on our recent I.E.E. paper ?

Reference is made to the use of a horizontal screen, and to the fact that it takes into account the light received from all sources. This is admittedly correct, and therefore it is by no means necessarily a reliable criterion of the sources of the illumination, since totally different results would be obtained with different surroundings. What is wanted is a system of measurement which will give a reasonably correct measure of the illuminating properties of the light source irrespective of the local conditions, otherwise it is impossible to compare different schemes on a common basis.

Reference is also made to Sir William Preece's idea of measuring the illumination on the ground. If illumination on a horizontal plane is taken as the basis of comparison, it should certainly be with reference to the ground level. Illumination on a horizontal plane essentially means on the ground surface, and, moreover, it is only by reference to the ground level that a fair comparison is obtained between lamps fixed at different heights.

We fail to see any great advantage in referring to a 3 ft. 3 in. basis so far as street work is concerned. The actual observations may be taken if possible on the ground level, or at any convenient level, and in this respect 4 ft. 6 in. is probably a more convenient height than 3 ft. 3 in., and it has the additional advantage that measurements of the illumination on a vertical plane may be taken at a height at which the rays concerned are probably most effective in facilitating the viewing of persons and vehicles, &c.

The author enumerates two advantages of the horizontal plane measurement. The second item is, no doubt, quite correct in so far as ease of measurement is concerned, but what it actually measures is the total rather than the impressed illumination, and

consequently the results are misleading for purposes of comparison unless all contemporary sources of light are tested under identical local conditions. Such a method of measurement takes full advantage of reflection from buildings and all stray light from shop windows or any other source.

The failure of illumination photometers with low values of illumination is admitted. They are handy, simple, and easy to use, but for accuracy can hardly hope to compare with candle-power photometers. They are very convenient for taking rough values of the total illumination from all sources on a horizontal plane either in buildings or in the street, but they are not so reliable as candle-power photometers for investigating the polar curves of lamps or other work requiring accurate candle-power measurements over a wide angular range.

With regard to the most satisfactory test for "the minimum" illumination, we think that the best criterion of the illumination of a street is probably provided by data giving the minimum value of the illumination on a horizontal plane at ground level and the variation factor, all photometric data being derived from direct ray measurements.

We cannot agree with the author in his remark on p. 252, viz., "Another result of these tests is to show that the ratio of maximum to minimum illumination is not a matter of importance."

This appears to us to be a most sweeping statement to make. No convincing argument is brought forward in support of it, and we venture to think that it is certainly contrary to the general trend of opinion. Absolute uniformity of illumination is admittedly unnecessary and probably undesirable, but there must at least be some reasonable limit to the extent of the variation factor. The low variation factor has had quite as much to do with the highly successful lighting of Portland Street and Princess Street, Manchester, as the high values of the candle-power and illumination obtained from the rival illuminants.

Mr. J. G. Clark (*communicated*):—I was much interested to hear Mr. Trotter's remarks in reply to the discussion last evening, and would just like to make a few observations thereon. Mr. Trotter adheres to the very close agreement between the photometric readings on the one hand, and the eye judgment of the surveyor members on the other, as his main argument in favour of rating street lighting by horizontal minima.

As I have already stated, I am of the opinion that the agreement has been somewhat overrated. The judgment by eye apparently failed to discern any great difference between streets having a minimum of ·011, and others having a minimum of 0·25 foot-candles, but surely if the photometric measurements mean anything, they mean that ·025 foot-candles is $2\frac{1}{4}$ times as great as ·011.

Mr. Trotter drew attention to the method of rating boilers by the quantity of water evaporated from and at 212° F., and its usefulness in comparing results in spite of the fact that boilers are never used in that way. I think, however, this analogy—and many others could, of course, be given—does not strengthen Mr. Trotter's argument. Physical quantities are usually much more easily interpreted than physiological and psychological quantities, and therein, I think, lies the difficulty in all lighting problems. It is gradually becoming realized that mere measurements of foot-candles, whether minimum, maximum or average, or on any surface whatsoever, can only *partially* indicate the value or usefulness of a system of lighting as judged by the sum of the human sensations, and it is this that accounts for the difficulty we often experience in our endeavours to reduce the problem of illumination to a standard form.

I have come to the conclusion that in order to reduce the problem to a standard specification, a more comprehensive method of evaluation than that provided for by the horizontal minimum illumination standard will have to be drawn up. It will, no doubt, involve a more complex statement, but the importance of the matter, I think, warrants it.

I should like to repeat that I quite

agree with Mr. Trotter as to the usefulness of horizontal measurements at a height of one metre for making comparison of results obtained here, and on the Continent; but I would prefer always to subordinate them to more complete data.

Mr. J. S. Dow (*communicated*):—After listening to the spirited discussion of this paper, I am sure we must all recognize the need of some form of compromise which will enable us to get the benefit of the classification of streets in terms of illumination (which, from a public standpoint, is sound, whatever the difficulties of measurement may be) and yet to meet the views of those who prefer to measure candle-power.

It would, no doubt, be unreasonable to rate as equally good two systems of lighting which provided the same minimum illumination but a very different total amount of light. But surely the fact that the specification requires a certain minimum illumination does not mean that contracts need necessarily be awarded on this basis alone. On the contrary, Clause 7 in the specification states that the position of lights is to be given, and Clause 8 provides for "particulars of lighting units," which might well include the polar curve of light distribution of the lamp to be tested. One may safely assume that the minimum illumination in a street is a requirement with which it should usually be easy to comply. It is designed to give an idea of the *least* illumination that can fairly be expected in various classes of streets. But according to present practice, in the case of many main streets, the award of a contract would probably turn much more on the excess of illumination provided above this minimum. In specifying this extra "luxury lighting," the mean (calculated) illumination in the street, or—what would probably give substantially similar results—the mean lower hemispherical c.-p. of the lamps might be stated.

It will be observed that objections to specifying illumination are not infrequently connected with the question of shading and the design of reflectors. Not long ago precisely similar objections were raised to measurements of illumination indoors. It was contended that "from a practical standpoint" it did not matter where the light was directed provided a certain candle-power (usually measured in the maximum direction) was provided. Now that people have come to understand better what shades and reflectors can do for indoor lighting we hear much less of this objection, and no doubt we shall see a similar development in connexion with street lighting. In truth a complaint that a thing is "not practical" often only means that some one is afraid of being put to trouble and is being reluctantly pulled up abreast of the times.

Mr. A. P. Trotter acknowledged the vote of thanks passed at the last meeting. It had been said that the gas industry was not well represented on the Committee. The Committee was representative of four institutions. They regretted the resignation of Mr. Doig Gibb, and further regretted that no one was nominated in his place. They must remember that their excellent Chairman was there as a representative of the Illuminating Engineering Society; the remaining delegates from that Society were neutral men so far as gas and electricity were concerned. There were about three habitual absentees among the electrical members, and one never put in an appearance at all, so the gas industry was not so badly represented.

They were not there to discuss street lighting or how to light streets. That might well be the subject for many meetings of the Society. Ingenious shades and so on might receive attention. But they were there to endeavour to describe street lighting in a concise way. Many seemed to have read the paper and given it up in despair before they got to the specification, which, after all, was the important thing.

The first question on which the great split had taken place was the choice between illumination and candle-power. The proposal before them was that illumination should be the criterion where it was not lower than 0·01 foot-

candle, and that where it was lower the candle-power basis would be adopted. The specification explained this quite plainly in Clause 3. It would have been better if the last paragraph of this had formed a separate clause, for it was undoubtedly the intention of the Committee that Clause 2, the first half of 3, Clauses 4, 5, and 13, should relate to illumination, and that the whole of the rest of the 15 clauses and the three special clauses should relate to candle-power as well as illumination. He had stated in his paper that the illumination method would cover only about 20 per cent of the street lighting in this country, and that it was proposed that the balance of 80 per cent should be measured by candle-power. In other words, four and a half clauses out of eighteen related to illumination, and thirteen and a half clauses related to candle-power as well as to illumination. But that statement had been taken to mean that "the specification legislated only for 80 per cent of the lighting of the country." So high an authority as Mr. Watson, one of the most useful members of the Committee, having made this slip, it had been seized upon by all the other gas engineers. The whole of their observations on that point were, therefore, quite beside the mark.

There was plenty of other good stuff in the specification which he thought would be very useful for candle-power work, and distinctly intended for that work. It was idle to suggest that Clauses 7, 8, 9, &c., were not applicable to candle-power work.

The cleavage had taken place early in the proceedings of the Committee. It had been a pleasure to engage in controversy with Mr. Watson, of Doncaster, who had given attention to the scientific side of the question, and with Mr. Goodenough, the courteous champion of the Bradley School. Mr. Bradley was a tough opponent who would not budge an inch. But it remained for Mr. Jacques Abady to import unpleasantness into the discussion.

The next question they had to deal with was the minimum. He was very glad to find that Mr. Watson agreed with the minimum, but it was not at present clear how they could combine that with a direct ray, which he so strongly advocated. The Committee, if they possibly could, should put a new clause in the specification which would enable them to use the direct ray which was advocated by so many engineers. The difficulty was that he did not see how Mr. Watson would find a minimum except by assuming that it came midway between two light sources. Calculation would be required if there were more than two as in ordinary staggered lighting, and complications would arise if the sources differed in candle-power. It was to be hoped that Mr. Watson's proposals could be worked into the specification. With the direct ray one had larger figures, and this gave a wider choice of photometers.

Mr. Clark said it was difficult to find the minimum, and Mr. Abady thought that an exploration and several measurements were needed. But nothing was easier. They could not have made eighty-eight measurements in one evening had there been much difficulty about it; in fact, they could generally see at once where it was, and it was only necessary to check it. In suggesting that it was difficult to find the minimum, Mr. Clark showed on the screen some illumination curves. These, as usually plotted, gave smooth curves, which were a testimony to his skill in photometry. He also showed part of the curve on a magnified scale, and this naturally revealed a variety of ups and downs. Mr. Clark had not been hunting for a minimum, he was taking sections, as it were, along certain straight routes. The main curve showed a general minimum region of 0·14 foot-candle, and a spot where the illumination was as low as 0·1. The application of Clause 13 would probably have ruled out this solitary observation.

Mr. Clark was one of those who thought that other factors than horizontal illumination had influenced the judgment of the surveyors in classifying the streets by eye.

Now he (Mr. Trotter) would have

great difficulty in defending the specification if it were not for the remarkable report of the surveyor members. He was going to pin his faith to the fact that the surveyors classified certain streets by eye, and their classes agreed exactly with the measurements of minima when placed in order of magnitude.

The first three cases, Cheapside, Whitehall, and Regent Street, in Fig. 3, were among the streets which they excluded. From St. James's Square down to Marylebone Road was the first class of the surveyors. Between Marylebone Road and Cambridge Street there was a measured difference only from 0·025 to 0·022 foot-candle. It did not amount to much, but it agreed exactly with the line drawn by the surveyors by eye. Reflected light and light from windows and houses, and the importance of direct ray in crossing streets and so on, had been referred to. The surveyors could not have shut their eyes to these; they must unconsciously have taken them into account for what they were worth. If the photometer report had not agreed with the surveyors' report these would have been good reasons for attempting to explain differences. But there were no differences!

Let us suppose that some fruit merchants graded a quantity of apples into three classes, and the fruit growers wished to discover on what principle the grading had been carried out. They might examine the colour, smell, firmness, weight, dimensions, and other points. Of these the weight could be most easily and accurately measured. Suppose they weighed each apple and found that the grading tallied exactly with the weights, would not they be justified in thinking that the merchants, though they must have observed the other points, had, for the purpose of their grading, been influenced, perhaps unconsciously, by the weights? At any rate, the fruit growers would be justified in acting on this assumption in future dealings with these merchants.

The next thing was the direct ray, which he was prepared to admit was most important. There was no doubt that in the streets the direct ray was probably the most useful one, and he would go further and agree with several speakers that the actual illumination on a horizontal plane in the street was not of importance, and yet Sir William Preece in about 1883 was the first to suggest that that was the thing to measure, and for many years after that that was what he (Mr. Trotter) did measure, and in his early work he measured at a level of six inches above the ground. When, however, the Committee came to consider a specification of how they were going to describe with a minimum amount of trouble and complication the lighting of a street, they must, as Mr. Roger Smith had said, take a conventional expression; and they took the illumination on a horizontal plane for various reasons, not because it was the most useful, but because it was one that they could compare, it being possible to compare different streets with the greatest ease.

In the second volume of the Society's Journal, Dr. Bloch, who was an electrical engineer of great repute, had given a table of illumination in various streets in Germany. There was a lot of information in the table—height, candle-power, spacing, and all sorts of things. What did they find in the last column but one?—"Minimum horizontal illumination." These were given in Hefner lux, of which twelve went to the foot-candle; and the measurements were all made at a height of 1 metre. So that they could compare any of the streets, and they could compare those Berlin streets with any street in London. Dr. Bloch there gave the minimum illumination which the borough surveyors took unconsciously as their criterion.

In the Society's Journal (vol. vii.), Dr. Bunte, at the German Gas and Water Engineers Meeting, gave a classification of streets. He spoke of taking exact measurements. He gave the lowest illumination permissible, which he (Mr. Trotter) supposed was the German equivalent for minimum illumination. In his classification, he gave for by-streets for little traffic 0·025 and 0·041 foot-candle. He (Mr.

Trotter) had divided Dr. Bunte's figures by twelve. There they had two examples of experts comparing—one by minimum illumination and the other by classification. This measurement on the horizontal plane was a conventional expression, to which they could reduce their measured illumination. Engineers were all familiar with conventional expressions. When measuring the evaporating power of a boiler fuel, they took the water evaporating "from and at 212° Fahr." Some engineers might say "What is the good of water at 212° for steam; It may be good enough for making tea." But before comparing the evaporating properties every engineer reduced them "from and at 212°." He did not like trespassing outside his own line, but he believed gas was measured by reducing to 60° Fahr. and 30 in. bar. Measuring for calorific power, he found in the Gas Referees' annual circular that a reduction was made to 60° Fahr. and 30 in. bar. This gave a basis of comparison, though perhaps in the course of the experiment one might never use that temperature or pressure. In the same way, having obtained the illumination by the direct ray, they had simply to use a table of cosines to convert to the horizontal. Perhaps that was too scientific; but it was rather an insult to anybody to say so. However, let them put in, if they could, something which would enable them to use the direct ray as advocated by so many engineers. He did not see how they were to be compared, or how they were going to be added together. Dr. Bloch, who had written about the horizontal plane, thought it was the plane upon which all illuminations automatically collected themselves.

Mr. Goodenough had given them six reasons against the specification. First, it ought to be comprehensible by members of local authorities. That was, indeed, a task! But the specification offers them certain classes. When a Town Council had to ask for street lighting they could under the specification ask for such an illumination as was to be found in St. James's Square, or somewhere else, and they would be able to imagine their own streets lighted to the same degree as any such example better than by bothering about candle-power, spacing, height and other matters.

Then Mr. Goodenough dragged in "the man in the street." Surely this important individual was concerned with the result, and the result only; and as he would eventually have to pay for it, he would prefer the cheapest method of arriving at that result, and would not care about polar curves or photometers.

"Thirdly, it should be of general and not limited application." Mr. Goodenough made this unanswerable statement, but did not explain how it applied to the specification. Fourthly, that it should not be open to being interpreted in such a way that the lighting of a street is reduced to an absurdity. That probably referred to the possibility that the whole street would be uniformly illuminated to the minimum. Mr. C. H. Sharp had observed "a street having a uniform illumination of 0·01 foot-candle would be a very dimly lighted street." That was obvious, but he (Mr. Trotter) contended that that was not possible, and that inevitable variations would give an average higher than the minimum. Dr. Louis Bell says "a call for minimum illumination is practically a call for small gas or electric incandescents glimmering along the street at intervals as infrequent as can meet the specification for illumination midway between them." Why glimmering? Why ask for a small minimum? If the intervals were infrequent the variation factor would assuredly be large, or, in other words, the minimum would be largely exceeded in many places.

Mr. Goodenough's fifth essential is that the specification should leave nothing to the discretion of the contractor. Was not this the backbone of Mr. Bradley's objection, the essence of all the opposition? He (Mr. Trotter) emphatically disagreed with it, for the reason that the lighting would have to be designed, and new methods, if any, invented, and the details proposed by the borough sur-

veyor. Unless they were going to have a class of men of great originality, they would never get any improvements at all. If, however, it was as stated what the result must be, there was some chance for originality not only in height, spacing, and the relation of the candle-power to them, but for different kinds of lamps, reflectors, and methods which he thought would produce what they all wanted, *i.e.*, better illumination everywhere. Surely the competition between electric lighting and gas had been one of the most important features of modern street lighting, and had led to great improvements. Mr. Goodenough had suggested that when one was hungry one did not go into a restaurant and say, "I have a certain standard of hunger which I wish to be appeased." One went and ordered a dinner. There was another way of doing it, which some of them who had travelled on the Continent, and were not very familiar with bargaining and so on, found useful. It was called *prix fixé*. One knew how much safer that was than venturing on *à la carte*. If they were going to light their streets *à la carte*, and going to specify all the fish, entrée, and everything else, the whole result would be a very serious responsibility in ordering that particular dinner which the ratepayer would have to eat and pay for, and probably the result in the end would not be much better than if one allowed the *chef* to arrange the menu of the *table d'hôte*.

When the Metropolitan Water Board desired to supply their new reservoir at Chingford with water from the Lea, competitive tenders were invited for pumping 180,000,000 gallons a day, the lift being 25 feet or 30 feet. Mr. W. B. Bryan would have been fully competent to draw a specification for a set of pumps of a particular pattern based on his wide experience. Tenders for six different methods were received, and the Humphrey gas pump was chosen. His courage in recommending this novelty has not only been justified by the results, but has constituted a most remarkable step in mechanical engineering. Inventors like Mr. Humphrey would not get such a chance as that offered by Mr. Bryan if the board had proceeded on the lines that nothing should be left to the discretion of the contractor.

Mr. Harrison's table had been held up to derision. The top right, and bottom left corners contained extreme cases derived from the formula; it might have been better to omit them. Mr. Trotter could not defend high candle-power lamps on short posts. He believed the tendency would be in the opposite direction, but he fancied that tall posts were going to cost something. Extreme height was controlled by Clause 8.

Mr. Trotter had not alluded to Prof. Morris's experiments in his paper, simply because he knew that there was more to be said about them. If it were attempted to measure the aggregate candle-power of a group of four or five lamps on a single lamp post, and then to measure them separately, precisely the same difficulties would arise, and the errors would probably be as great.

Mr. Goodenough quoted Dr. Louis Bell, who seemed to think that a contract involving £50,000 or £100,000 a year would be received at per foot-candle and that a difference of 2 or 3 or 5 per cent would be a serious matter. This is not proposed, and it would be equally foolish to base a contract at per candle-power. No specification could be drawn without limits. What was proposed was a simple limit.

Mr. Bradley's remarks on the basis of his twelve years' experience, of course, demanded very serious consideration, but he (Mr. Trotter) had alluded in his paper to the experienced surveyor who, having studied his own district, could say precisely what was necessary for that district. This was not a Westminster specification. It was meant not only for London, but for England, the Continent, and possibly America too. It was by no means a parish specification, though the parish of Westminster was probably the most important one in the world. The same speaker alluded to the weather, painting of houses, trees, &c.; but as to trees and weather the Committee had dealt

with them in the specification, and some proof must be brought that painting the houses had any effect on the illumination. Mr. Allen suggested that the specification should be taken back for further consideration, but he thought that had been sufficiently answered by Mr. Gaster. The specification was only in draft, and he hoped that it might be improved. Mr. Roger Smith spoke of the question of glare, which, however, had not been omitted. That phase of the subject was prominently before the Committee, and they had put in Clause 8 with the express idea of taking care of glare He humbly accepted Mr. Cooper's rebuke about diversity factor, which he might have used verbally, but he thought that the expression did not occur in his paper. Variation factor was undoubtedly the word for it.

He finally came to Mr. Jacques Abady. Mr. Goodenough had said that the specification was too scientific. Mr. Abady was reported to have said that it was stupid and unscientific, and they had heard him express his undisguised contempt for it. These two arguments might be left to destroy each other were it not that the authorities are unequal. Mr. Goodenough is thoroughly conversant with the matter, and Mr. Abady has exhibited lamentable ignorance of it. Mr. Abady let the cat out of the bag when he said that the specification would have been a *fait acccompli* if it had not been for him. In other words, the Institution of Gas Engineers must have been prepared to accept the specification when Mr. Abady forced his mistaken views on them. The delegates of that Institution had had the matter before them and had no doubt come to a matured opinion. Mr. Abady not only knew nothing of the discussions which had led to the specification, but his report on the Manchester lighting, and his remarks on this occasion, showed that he was one of the few men who completely misunderstood the matter, and, perhaps, the only one who did not know what was meant by illumination. This he admitted when he said that they could not dissociate the lighting effect from what was being illuminated; they could not dissociate illumination from the source nor from the surface which received it. Mr. Abady, failing to understand what illumination was, asserted that they "did not see anything in any other way but by illumination." Could he account in this way for the scandalous glare of some shopkeepers, lamps, notably of some outside tobacconists' shops? Mr. Abady had quoted from the paper but ignored the context. For example at about 80° it is true that "an error of 1° makes about 10 per cent difference at this angle." The next word was "But," and opened a sentence explaining why this led to no difficulty in the circumstances.

Some engineers seemed to think that a scientific trap had been laid for them. They were entitled to take the position that they did not wish to make any calculations about spacing lamps or to take any part in the design of street lighting, and wished only to carry out the work to a specification which left nothing to their judgment. But others were entitled to offer to act as engineers rather than as merchants; to experiment, to calculate, to design and plan the most efficient method of carrying out a problem of street lighting, rather than to sell lamps which were kept wrapped up in brown paper on a shelf. He would like to add, in conclusion, that the draft specification, faulty though it might be, was, both in intention and in fact, free from anything that could favour or prejudice either the gas or electrical industries.

ERRATA.—In the May number, p. 274, in the second line of the second paragraph, for "main horizontal illumination," read "mean horizontal illumination."

Some Notes on the Standard Specification of Street Lighting.

By W. J. Liberty (*Inspector of Public Lighting for the City of London.*)

I regret time did not allow me to take part in the discussion upon Mr. Trotter's paper. Had I done so, it was my intention to have given some data which I have collected during many years of experience in the City of London, especially with regard to the large number of experiments made with gas and electricity in the City during the last ten years down to the "last word" in street lighting. It was also my intention to have put this information upon the screen from slides I had prepared, but perhaps it will answer the purpose better if I accept the Chairman's kind suggestion to send them in for reproduction in the *Transactions* of the Society, for use among a still larger number of members, especially as the draft specification is going back to the Committee for further consideration.

First, however, let me remark that I agree with Mr. Watson of Doncaster that 10 ft. is not the correct height for the low-illumination lamps on columns; 12 ft. (certainly not less than 11 ft. 6 in.) is found in practice to be the lowest the lamp should be fixed; at that height they are above the line of vision.

The following are a few diagrams giving heights and spacings, also views of street lighting at night of various streets at home and abroad, with polar curves of some of them. Readers may also be referred to the diagrams and tables accompanying Mr. Voysey's report on the City Lighting in 1908 (see Illum. Eng., Lond., Vol. I., 1908, p. 561).

They show in particular the following:—

(*a*) Heights of lamps above the footway or carriage-way.

(b) Distances apart of lamps.

(*c*) The width of the roadway.

(*d*) Polar curve (where possible).

(*e*) Long brackets over the footway.

(*f*) Columns on the side-walk.

(*g*) Columns down the centre of the roadway.

(*h*) Centrally hung lamp (gas and electricity).

Fig. 1 makes it evident that our friends in the United States favour a zone considerably lower than that customary on this side of the water. Table I, comtaining some data on Continental practice shows that Paris also favours low columns.

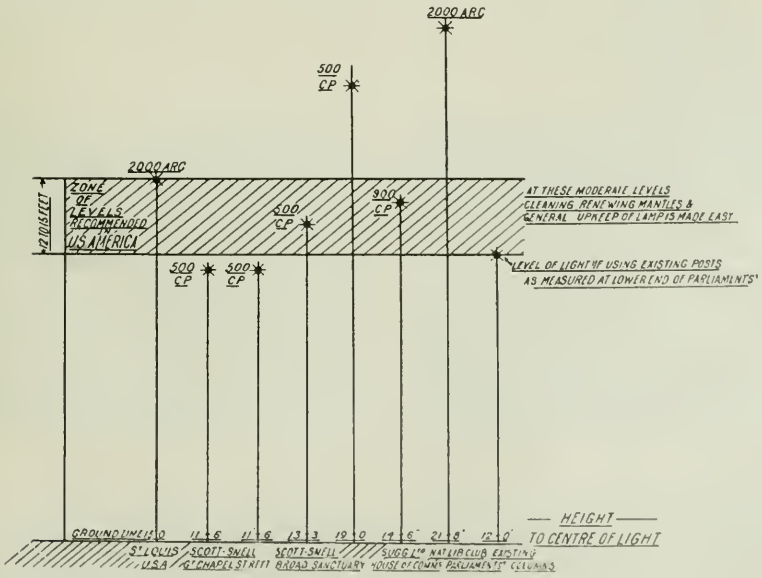
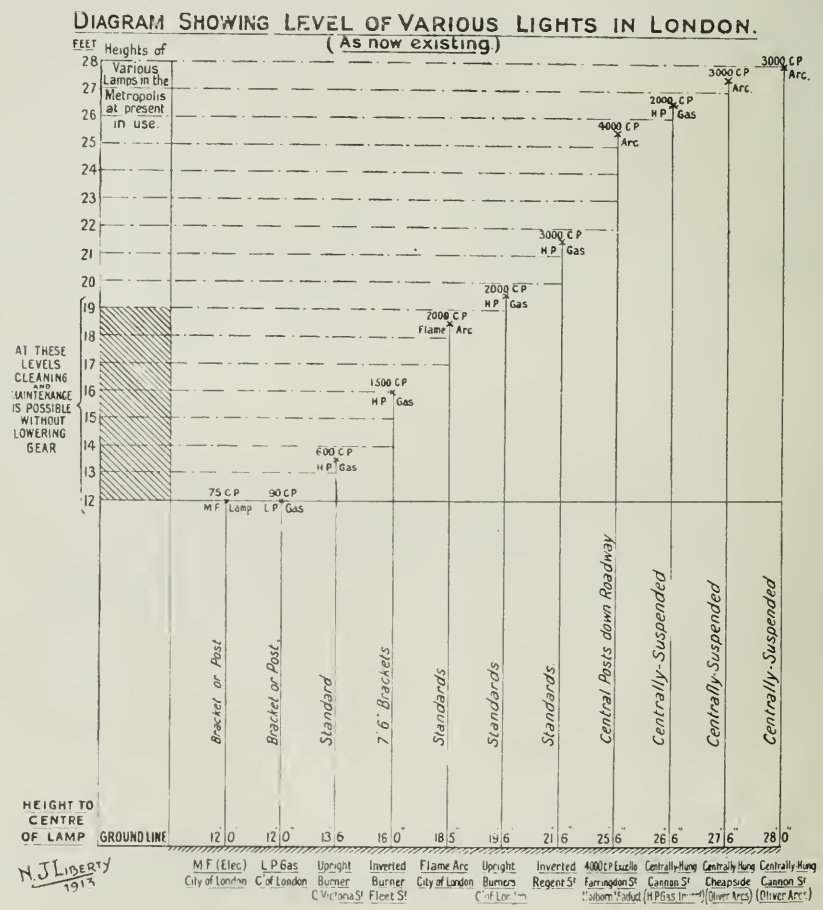


Fig. 1– Comparing heights of Lamps common in this Country and in the United States.

HEIGHT OF LAMPS.—CONTINENTAL CITIES. 1909.

Name of City	Flame Arc Lamp	Electric Glow Lamp	H. P. Gas Lamp	Low-Pressure Gas Lamp
	Posts (in feet)	Posts (in feet)	Posts	Posts
BERLIN	26 to 39·52	—	14 ft. 7 in. to 18 ft. 7 in.	11 ft. 5in. to 14 ft. 7 in.
BRUSSELS ...	—	—	—	11 ft. 5 in. to 14 ft. 7 in.
COLOGNE ...	26 to 33	11·5	—	11 ft. 5 in.
DRESDEN ...	26	10, 16, 26	—	10 ft. 6 in.
DUSSELDORF ...	29 to 33	—	—	10 ft. 2 in.
MUNICH ...	33	13	—	11 ft. 5 in.
PARIS	13 to 20	—	—	11 ft. 7 in.
VIENNA	26 to 39	—	23	11 ft. 5 in.
STUTTGART ...	—	—	Centrally Hung 24 ft. to 28 ft.	—

N.B.—Heights are from Roadway to Burner.



The diagram on the opposite page may be conveniently compared with Table I., and shows the level of lamps customary in the Metropolis, including centrally suspended, experimental and permanent systems, the heights and spacing having been decided upon according to the nature of the thoroughfare and the experience gained as regards the requirements of traffic.

We now come to a series of night views of London streets, photographed entirely by artificial light, that may be of interest :—

FIG. 1. Cheapside lighted by centrally suspended Oliver Oriflamme magazine flame arcs, fitted with Peard prismatic reflector (12½ amp., 3,000 c.p.). Height above roadway 27 ft. 6 in., average distance apart 90 ft. General width of roadway 50 ft. Alternate lamps extinguished at midnight.

FIG. 3. Queen Victoria Street with lanterns on footpath. High-pressure gas (10 in. pressure), 600 c.p. lamps are used. The height of burners is 13 ft. 6 in., their distance apart 100 ft, and the width of street 50 ft.

FIG. 2. Night view of Fleet Street lighted by high-pressure (54 in. water) gas lamps (1,500 c.p.), on long brackets 7½ ft. from house front. Height 13 ft. and 16 ft. Distance apart 120 ft.

FIG. 4. Eastern end of Cannon Street, lighted with central high-pressure inverted (80 in. water) gas lamps (2 burner, 1,500 c.p.). Average distance apart 104 ft. General width of street 50 ft.

The following diagrams give particulars of the illumination derived from various modern illuminants in some of the streets referred to above.

The final illustration on the next page gives the details of the suspension gear, now being used for lamps hung over the centre of the roadway.

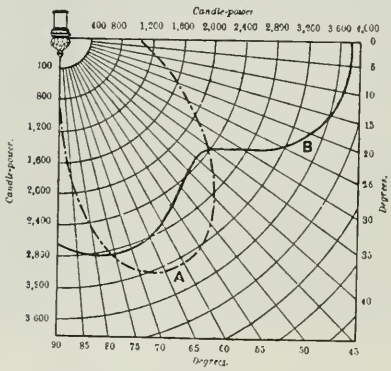


FIG. 5. Polar Curves of 12½ amp. Oriflamme Lamp (Cheapside). A = With ordinary light opalescent outer globe. B = With clear outer globe and a "Peard" Prismatic reflector. Note the increased intensity at small inclinations to the horizontal as a result of the latter arrangement.

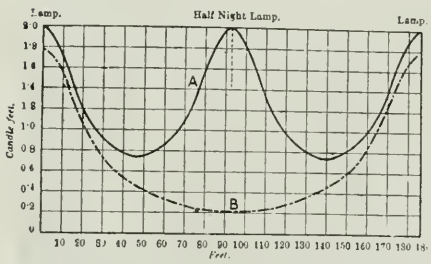


FIG. 6. Horizontal Illumination along ground at Kerb Line in Cheapside. Curve A = Illumination until midnight. Mean = 1·23 candle-ft. Min. = 0·72 candle-ft. Max. 2·00 candle-ft. Curve B = Illumination from midnight to sunrise. Mean = 0·66 candle-ft. Max. = 1·78 candle-ft. Min. = 0·22 candle-ft.

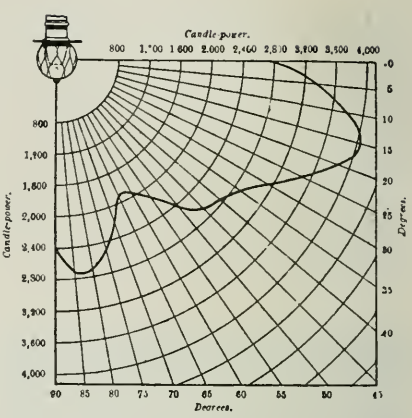


FIG. 7. Polar Curve of 12½ amp. Excello Arcs with Dioptric Inner and Semi-opalescent Spherical Outer Globes (Farringdon Street). Height of Lamp 25 ft. 6 in. Spacing about 175 ft. Width of road 100 ft.

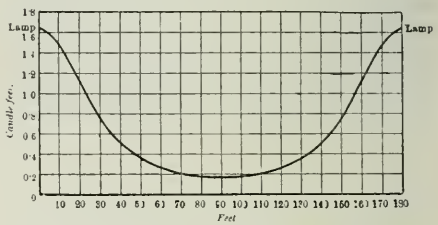


FIG. 8. Horizontal Illumination along ground at Kerb Line in Farringdon Street. Mean illumination = 0·67 candle-ft. Min. illumination = 0·17 candle-ft. Max. illumination = 1·64 candle-ft.

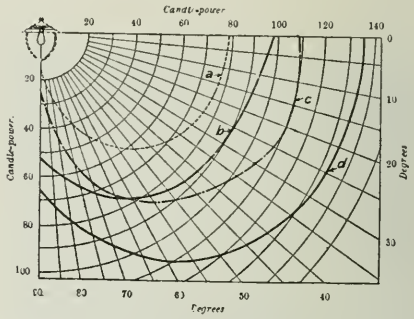
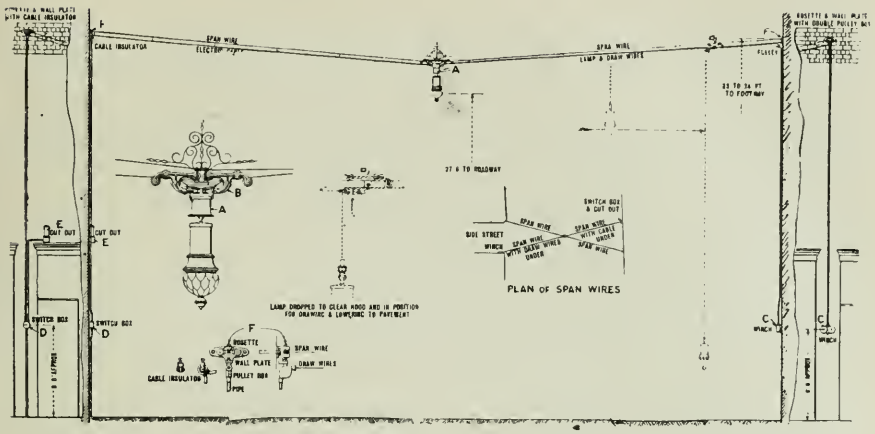


FIG. 9. Candle-power Polar Curves of Metal Filament Lamp Fittings. a = 75 c.p. lamp (isolated). b = 75 c.p. lamp contained in street fittings, with reflector and shade. c = 100 c.p. lamp (isolated). d = 100 c.p. lamp contained in street fittings, with reflector and shade. These are used in side streets on brackets 12 ft. above pavement, 86 ft. apart. General width of street, 20 ft. This corresponds with the 80 per cent electric street lighting that is unclassified.



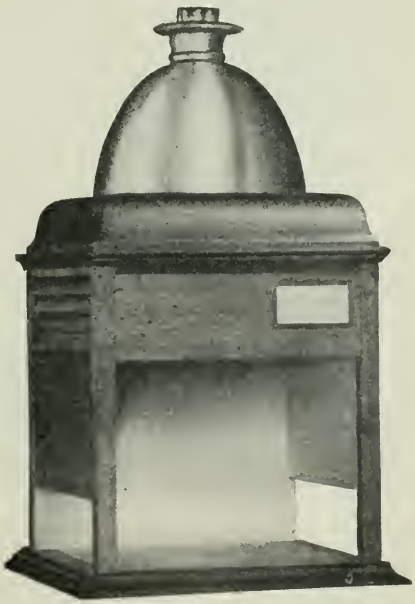
CENTRAL SUSPENSION SYSTEM (CHEAPSIDE).

These details of actual practice may be of some use, although there are other factors of a local character always to be taken into account :—

For instance, Cannon Street and Cheapside—two parallel roads in the City of London—are each lighted with centrally hung flame arc lamps. Both thoroughfares are approximately the same width, yet the spacings are 138 ft. and 90 ft. respectively, the reason being that the former road is used principally for through traffic, and has an absence of shops, whilst the latter is crowded with pedestrians, and full of shops and plate glass. The nearness in the spacing of the latter is counterbalanced by the fact that alternate lamps are extinguished at midnight. This illustrates how special consideration must always be given to localities.

ARTIFICIAL DAYLIGHT WITH GAS.

It appears that Dr. H. E. Ives has now produced a screen which can be used with an ordinary inverted incandescent mantle to produce artificial daylight. Although screens of this kind for use with tungsten lamps have been developed by Dr. Ives in the United States, and also by Dr. Kenneth Mees in this country, this would seem to be the first time that the method has been applied in a practical form for gas. The illustration shows the general appearance of the apparatus. It consists in a box receptacle, whitened inside, which receives light from the inverted mantle within the dome-like reflector mounted above it. Underneath this reflector there are two double plates of glass, the colour of which is selected with a view to securing an exact imitation of a natural north light. We understand that the Welsbach Co. in the United States are already manufacturing this novelty.



An Interesting Semi-Indirect Lighting Office Installation.

By An Engineering Correspondent.

The lighting of a large office, although it may appear at first sight a simple problem, needs a little care. It is often assumed that if one provides an adequate illumination on the desks, and puts the lamps at a sufficient height to avoid serious glare, one has done all that is necessary. But there are other matters to be considered.

It is hardly enough to ensure that there is no glare within the "ordinary range of vision." The wandering eye, even if directed upwards towards the ceiling, should never meet a surface of disagreeable brightness. Full use should also be made of reflection from white surroundings so as to avoid unduly dense shadows from the hands or persons of people working in the room.

These considerations favour the use of semi-indirect lighting. Other advantages are that the glare effect from shiny paper is reduced to a minimum, and that the light, coming from a large luminous surface, can penetrate into corners of the room—a point which is of considerable importance in offices where legal work is done, and where it is usually necessary to light up the vertical racks and pigeon holes.

The two illustrations facing this page refer to a semi-indirect installation at the branch of the Liverpool and Victoria Legal Friendly Society at Stamford Street London, E.C. The room shown in Fig. 1 has an area of approximately 1,350 sq. ft. and is illuminated by 11 Benjamin Semi-Indirect Units, each containing three 50 watt tungsten lamps. The specific consumption works out to roughly 1.25 watts per square feet, and the illumination on the desks and tables, which is very uniform, is about 4½ foot-candles.

Owing to the amount of detail work in this office (filling in forms, &c.), this high value of the illumination is distinctly advantageous, and there is also ample light thrown vertically on the cases lining the walls.

Each of these units has a specially designed translucent white glass Reflector Bowl, completely screening the lamps from the eyes of workers, while the upper portion consists of a curved enamelled white "deflector," which distributes the light over a wide area. A certain amount of light is allowed to escape between the bowl and reflector, and illuminates the white ceiling; but the deflector described above (which can easily be cleaned) enables the system to be used successfully even when the ceiling is not a dead white tint.

There are in the building four large offices lighted in this way, 50 semi-in-direct units in all being installed.

The second photograph showing the figures seated at the desks is of special interest. This was taken without flashlight, and simply by the ordinary artificial light in the room. To take photographs with figures under these circumstances is something of a feat, and is only practicable when the illumination is exceptionally high.

For the illustrations and some of the information conveyed in this article the writer is indebted to the Benjamin Electric Co., Ltd.

FIG. 1.—Photograph of an office of the Liverpooi and Victoria Legal Friendly Society (Stamford Street, London, E.C.), taken entirely by artificial llght, and showing the illumination by Benjamin Semi-Indirect Lightlng units. The illumination is about 4½ ft-candles, the consumption of electricity approx. 1¼ watts per square foot.

FIG. 2.—Another short-exposure photograph of the same installation, also taken entirely by artificial light

REVIEWS OF BOOKS.

How to Know Architecture. By FRANK E. WALLIS. (Messrs. Harper & Brothers, London and New York, 1910.)

READERS of this journal will recall a conversation with Mr. Frank Wallis, recently published in these columns, and advocating a closer relationship between the architect and the illuminating engineer.

It is often said that the architect needs to know more of illuminating engineering; but it is equally true that the illuminating engineer who wishes to attempt the highest class of work ought to study architecture. Mr. Wallis has been closely associated with both professions in the United States, and his readable introduction to the knowledge of architecture should be read with interest by many of those engaged in engineering work.

The history of architecture is closely associated with human relationships and the development of ideas. Mr. Wallis shows how the primitive buildings of early times gradually changed their nature with the opening of the great trade routes from the East, and the growth of Grecian and Roman culture. He traces the gradual transitions in style following the Greek and Classic period and the development of the Romanesque, Gothic, Renaissance, and other styles, all characteristic of the changes in the social fabric of mankind.

American architecture is naturally very complex, and reflects the diversity of its population. At one time it was somewhat decadent, but now seems likely to develop into something more homogeneous and characteristic. The chapters devoted solely to the architecture of England are also particularly interesting.

In the final portion of the book Mr. Wallis deals with the future, and the great opportunities before modern architects in connexion with the design of large offices, stores, and public buildings. Here, then, is a growing demand for something at once imposing and serviceable. In this modern work particularly we should like to see the scheme of lighting worked out while the nature of the building is still under consideration. Co-operation between the architect and the lighting engineer in these early stages would often make all the difference between a mediocre and a highly successful installation.

Mr. Wallis's book contains 327 pages of matter and over one hundred excellent illustrations. It should be read with interest, even by those who know little or nothing of architecture.

Electrical Photometry and Illumination. By H. BOHLE, Professor of Electrotechnics at the South African College, Cape Town. (Chas. Griffin & Co., Ltd., London, 1912. 10/6 net.)

THIS book, the author states, is intended primarily for students, but it is hoped that it will also be of some use to architects, medical men, and others. In the Preface Prof. Bohle lays special stress on the small interest taken by architects in lighting problems. (He mentions that a certain recently erected building cost £20,000. The sum allocated by the architects to lighting was only £100, or about 0·5 per cent of the total—surely a most inadequate figure, especially as the building was largely used for entertainments by night.)

We think, however, that the book will be mainly useful to students who desire a concise summary of the subject, for much of the matter is presented in a somewhat condensed and technical form. The course of the book is not unlike that adopted in most treatises of this kind. It contains 222 pages, the early chapters dealing mainly with photometry, the middle ones with lamps and shades, and the final portion with general illuminating engineering. It is, however, brought more up to date than most existing works in the English language, and the author acknowledges the assistance derived from the work of the *Illuminating Engineer* and the Illuminating Engineering Societies during the last few years.

A good feature is the series of references to literature on illumination which are collected together at the end of the book.

Competition Points for Gas Salesmen. By A. F. Bezant. (Walter King, Office of 'The Journal of Gas Lighting,' 11, Bolt Court, Fleet Street, London, E.C., 1912.)

This little book, containing upwards of two hundred pages, is intended as a help to the gas salesman. It is therefore frankly controversial, although in the Preface the author is careful to explain that he has endeavoured "to avoid all extravagance and misrepresentation, which are too often found in electrical advertising literature."

The book opens with a discussion of the comparative costs of gas and electric lighting, and the author shows an acquaintance with much that has been written on this subject by electrical engineers, as well as in periodicals devoted to gas lighting. The assumptions involved in these calculations will be tolerably familiar to our readers. But there is one point that constantly crops up in all comparisons of illuminants, namely, the interpretation of the figures given for candle-power. It is well known that the candle-power of lamps is often measured in a maximum direction only, and the nature of the reflector used with the lamps may then make a considerable difference. This matter is of some consequence in the comparison of sources having such widely different polar curves as the metal filament lamp, the flame arc, and the incandescent mantle. Possibly in the future all such comparisons will be expressed in terms of mean spherical candle-power. This takes into account the light in all directions, and would seem to be a sounder basis of comparison.

Following this will be found a discussion of the life of metallic filaments and mantles. Here again the author judiciously selects his quotations from various gas and electrical authorities.

The next point dealt with is intrinsic brilliancy. Mr. Bezant, in order to emphasize the glaring effects of unshaded metal filament lamps, makes frequent quotations from papers read before the Illuminating Engineering Society. In a subsequent chapter he raises the same point in connexion with the use of flame arc lamps outside shops, remarking that "unprejudiced scientific lighting engineers protest against these lamps being hung at such low levels." We need not say that we entirely agree as to the desirability of proper methods of screening in connexion with these brilliant sources, but we should like to add in passing that these remarks do not apply to electric illuminants alone. We are glad to see that Mr. Bezant brings home to the gas salesman the need for effective shading, remarking that the main object in shop lighting is the illumination of the goods in which the tradesman deals, and not merely the display of lights.

Subsequently, we find short chapters dealing with the colour of illuminants and artificial daylight, factory and workshop lighting, fogs and light penetration, &c. Here, again, frequent reference is made to papers read before the Illuminating Engineering Society. We notice that in the chapter on fogs and light penetration reference is made to the famous controversy of the last century on the relative merits of oil and electric lights in lighthouses.

The author next presents a summary of events in connexion with the public lighting in various sections of London, special attention being naturally devoted to the introduction of high pressure gas in Westminster.

He then passes on to the familiar controversy of the hygienic aspects of gas and electric lighting, marshalling his authorities in an imposing manner, and endeavouring to show that a well designed modern gas lighting installation is not prejudicial to the atmosphere, and that it actually assists ventilation. Authorities are also quoted in favour of the view that gas lighting is in no way injurious to plant life.

This book is written in a very concise and readable style, and should prove of interest to many who are not identified with gas lighting. As our readers are well aware, we ourselves advocate the gradual elimination of undue bitterness in the competition between gas and electricity. We are bound to say that Mr. Bezant, while naturally making the best of his case, takes a moderate tone. A good feature is that he almost invariably quotes authorities in support of his statements, so that readers who so desire can look up the literature for themselves. Sandwiched in between what may be termed the "competition" areas of the book will be found much useful information put in a compact form. It is interesting to observe the importance attached by the author to the study of lighting problems and illumination. We feel sure that the encouragement of such study can do a great deal for the gas industry, and that there are great possibilities in the development of the scientific treatment of gas lighting.

Electricity for Everybody. By W. Borlase Matthews. (Electrical Press, Ltd., 37–8, Strand, London, W.C., 1912.)

A new edition of this little work was published in 1912, and it may conveniently be noticed in conjunction with the work referred to above. The aim of the author is substantially the same, but he covers somewhat wider ground, and necessarily presents his information in a very compressed form.

The book is divided into four divisions, entitled respectively 'Electric Lighting,' 'Electric Cooking and Heating,' 'Electric Power,' and 'Hints to Canvassers.' The first and last sections will be most useful to our readers.

The amount of information conveyed is very considerable. The chief points in lighting an average residence, the costs of wiring, and the factors on which the lighting bill will depend are concisely stated. Several chapters deal with shop lighting, advertising signs, and the illumination of factories and public buildings, and tables for the number of lamps and the consumption are given.

Under the heading of 'Candle-Power and Photometry' the author explains the chief units, and gives the illumination suggested for various classes of work, the watts per square foot, and the usual rules for candle-power per square foot. Much of this will be found of value, but we think that in a few cases the matter might be brought more up to date by reference to some of the recent work of the Illuminating Engineering Society. The author has adopted throughout the method of putting information into the smallest space, and perhaps for this reason gives few references to the source from which information is taken.

On p. 85 he gives a table comparing the costs of gas and electricity. We notice that this is based on a comparison between carbon filament electric glow lamps and flat-flame gas burners. The author assumes "that the comparison is practically the same for metallic filament lamps and incandescent gas burners"; but it would surely have been far better to work these costs out anew on the basis of modern types of lamps, and we hope that this table will be corrected in the next edition. In comparisons of this kind it is surely essential to be thoroughly up to date.

The remainder of the book is devoted mainly to wiring data, electric heating, domestic and industrial applications of power, tables giving the horse-power required for various purposes, &c.

In conclusion, the author gives some advice to consumers. We are glad to see that he, like Mr. Besant, insists that the canvasser should be thoroughly conversant with modern methods of illumination, and that he should recommend judicious and artistic methods of lighting in preference to those that are open to objection on the ground of glare, and excessive brilliancy.

A series of arguments are also suggested as a means of inducing consumers to adopt electricity in place of gas. These, however, consist mainly of general statements, and would probably be more serviceable if backed up by actual quotations from authorities. We are opposed to arguments depreciating a rival illuminant, and think it is in general a far better policy to supply canvassers with up-to-date information respecting their own method of lighting. In this direction there is still room for enterprise.

The book concludes with a series of pictures of installations and appliances. We notice that the photographs, apparently intended to show how various rooms should be lighted, are all taken by daylight, and that the types of shades used in one or two instances are distinctly unsatisfactory. In a future edition we should recommend these being replaced by photographs of up-to-date installations taken entirely by artificial light. Successful photographs of this kind are invaluable to the canvasser.

The book now contains upwards of three hundred pages, most of them in close type. We have offered some suggestions for its improvement, but we have no doubt that the information it contains will be appreciated by many of those in the electrical industry.

Kalendar für das Gas- und Wasserfach 1913. Compiled by Dr. E. Schilling and G. Anklam. (Münich, R. Oldenbourg, 5m. 50, bound.)

This calendar contains over 250 pp. of closely set matter, brought up to date in October, 1912. The information is divided into two sections, devoted respectively to the use of gas and to hydraulic matters. The work contains a calendar and pages for stray notes, and concludes with a list of the chief gas, electric, and acetylene companies in Germany.

The book is provided with a receptacle for papers, and can be conveniently inserted in the pocket.

Review of the Technical Press.

ILLUMINATION AND PHOTOMETRY.

THE bulk of the interesting matter this month occurs in the American publications, notably the *Transactions* of the American Illuminating Engineering Society. ALGER (*T.I.E.S.*, March) discusses **Illumination and Eye-Strain.** He points out that many physiological effects previously ascribed to heat are now believed to be due to the chemical effect of light rays, and he suggests that yellow rays in general cause the least fatigue. The paper contains a useful list of references to the work of Ulthoff, Koenig, Langley, and others. HUNTER (*T.I.E.S.*, March) deals with the **Lighting of the Home** which he regards mainly as a decorative problem. He adopts the rule on which one 16 c.-p. lamp per 50 sq. ft. of floor is allowed. He gives some interesting experiences in connexion with his attempt to substitute light "ivory white" lacquer for the dark varieties usually employed. It appears that the dark material is not used because it is more decorative, nor because it is better from the lighting standpoint, but merely because it happens to be slightly cheaper.

Cinematograph Work and the effect of moving pictures on the eyes is discussed by J. F. MARTIN (*T.I.E.S.*, April) and A. L. ALTENBURG (*Optical Journal*, April 24th). The various things that may cause eye-strain are discussed in detail. The effect is very often caused by poor films and unsteady lights. Martin states that the usual value for the illumination of the screen is 0·4 foot-candle, the value in the auditorium being nearer 0·2. He also alludes to the factors controlling the brightness of the screen. Aluminium powder screens are sometimes used, but the best results are obtained from plate glass specially backed with opaque white. The paper also contains some particulars of the consumption of arc projectors.

Turning now to papers of a more scientific character, we may note that by FORD (*T.I.E.S.*, April), who discusses the screen to be used with a photometer for general measurements of illumination. Measurements in a horizontal plane are recommended, but it is suggested that it would be better if a form of screen collecting the rays from all directions could be devised. The author has therefore made experiments with a sphere made of alba glass, blocks of translucent material, &c., and he gives the results of these tests in his paper.

LUCKIESH (*Electrical World*, April 26th) gives the results of some tests of **Diffusing Glass Ware.** He makes an attempt to define the diffusion co-efficient of obscuring glass, and determines the transmission factor for a number of different varieties. An important point to notice is that light that is not transmitted is not necessarily lost, but may be merely reflected. A very interesting research on the **Absorption of Light by Water** was described in *The American Chemical Journal* for April. The author's comment on the curious fact that solutions containing certain materials (mainly hydrates) appear to absorb light to a smaller extent than pure water, a result that is very difficult to explain theoretically. They also present curves showing how the absorption of light varies through the spectrum. This again depends on the salt in solution, but the absorption is usually greater for rays of short wave length.

ELECTRIC LIGHTING.

There are a number of articles dealing with the manufacture of **Metal Filaments.** H. ERB (*Licht u. Lampe*. April 24th) gives an interesting analysis of the cost of the various operations. A considerable reduction in price of metal filaments, amounting to about 30 per cent. has been made on the Continent, and this matter is commented upon in a number of journals. REMANÉ presents a series of life curves of metal filaments, and gives particulars of their use on tramways and for motor-car headlights. He finds that the new high candle-power lamps consuming 0·8 watts per H.K. only diminish in light by about 8 per cent in the course of 1,000 hours. C. F. LORENZ (*Electrical World*, May 3rd) describes a method of spot-testing filaments. He examined them against a uniformly luminous background. In these circumstances only the brightest portions of the filament stand out, and the duller portions can be made

to vanish. Any inequality in brightness is thus readily detected.

Other papers deal with the newly introduced long-burning flame arc lamps in the United States. Thus the G.E.C. enclosed arc is said to burn 100-120 hours without attention. It uses vertical carbons.

GAS, OIL, AND ACETYLENE LIGHTING.

There are several articles contrasting the cost of electric and gas street lighting. F. Kropf gives some examples of the use of high candle-power gas lamps in photographic studios, and H. Pickhardt enters into the **Artistic Possibilities of Gas Lamps.**

Attention has also been given to flashing gas illuminated signs, which do not appear to have been yet exploited as much as they deserve.

There have been an exceptional number of articles dealing with **Acetylene Lighting,** some of them dealing with the recent Congress in Philadelphia. P. Rosemburg describes the use of acetylene in the French army. In the recent manœuvres the value of portable lights in hunting for the wounded was demonstrated, and acetylene is now being used to a great extent in medical service. Other articles deal with the lighting of small towns by acetylene and electricity, and the recent results obtained in connexion with the acetylene buoys. These are very largely used in the Swedish Marine, installations carrying from 5,000 to 130,000 litres of gas being common. Such installations will last about two months, and give about 300 candle-power. *Licht u. Lampe* (April 24th) contains a readable article on **The Development of Oil and Petroleum Illumination** from the early times of the past up to the incandescent oil units of the present day.

List of References:—

ILLUMINATION AND PHOTOMETRY.

Alger, E. M. Illumination and Eye-strain (*T.I.E.S.*, March).
Altenberg, D. L. Motion Pictures and Eye Fatigue (*Optical Journal*, April 24).
Crouch, L. Cost and Efficiency of Display Lighting (*Electrical Review*, March 28).
Editorial. A Study of Street Lighting (*Elec. World*, April 19).
Investigation of Diffusing Glassware (*Elec. World*, April 26).
Farrar, H. L. A Convenient and Reasonably Accurate Photometric Standard (*Gas Age*, April 15).
Ford, A. H. A Photometric Screen for Street Lighting (*T.I.E.S.*, April).
Harris, H. C. Theatre Illumination (*Elec. Review, N.Y.* April 19).
Hirschberg, L. K. Lighting the Panama Canal (*Am. Gaslight Journal*, April 14).
Hunter, G. L. Home Illumination (*T.I.E.S.*, March).
Jolley, L. B. W. The Science of Illumination (*Builder's Journal*, April 2).
Luckiesh, M. Factors Involved in the Use of the Flicker Photometer (*Elec. World, N.Y.*, April 10).
Investigation of Diffusing Glassware (*Elec. World*, April 26).
Martin, J. F. Illumination of Motion Picture Projectors (*T.I.E.S.*, April).
Millar, P. S. Some Phases of the Illumination of Interiors (*T.I.E.S.*, March).
Pfotenhauer. Bewerkung von Lichtquellen (*J. f. G.*, April 19).
Rennie, G. K. Streetlighting (*Am. Gaslight Jour.*, April 7).
Rolph, T. W. Principles of Industrial Lighting (*Industrial Engineering*, April).
Schaeffer, E. J., Guy, J. S., and Jones, H. C. The Absorption of Light by Water (*Am. Chemical Journal*, April).
Factory Lighting Legislation in the United States (*T.I.E.S.*, April).
Halbindirekte Beleuchtung (*Z. f. B.*, April 10).
Light Redeemers (*Edison Monthly*, April).

ELECTRIC LIGHTING.

Caldwell, J. Electric Lighting of Small Country Houses (*Elec. Review*, April 18).
Darrah, W. A. Flame Carbon Arc Lamp (*T.I.E.S.*, April).
Editorial. Free Renewals of Tungsten Lamps (*Elec. Review, N.Y.*, May 3).
Spot Testing of Incandescent Filaments (*Elec. World*, May 3).
The Cadium Amalgam Vapour Lamp (*Elec. World*, May 3).
Erb, H. Fabrikation und Preisstellung in der Glühlampen Industrie (*Licht u. Lampe*, April 24).
Krub, O. Über die Herstellung von gezogenen Wolframdraht (*Elek. und Masch.*, April 20).
Lorenz, C. F. A Method of Spot-testing Incandescent Filaments (*Elec. World*, May 3).
Lampmaker, A. The Tungsten Lamp Position (*Elec. Times*, April 24).
Remané, H. Die Osram Drahtlampe (*Die Welt der Technik*, No. 7, pp. 130-134, 1913).
Thieme, B. Quarzlampe f. techn. und medizn. Zwecke (*E.T.Z.*, May 8).
The General Electric Long Life Flame Arc Lamp (*Elec. Rev. N.Y.*, April 12).
The Future Street Lighting of Chicago (*Elec. World*, April 12).
Moderne Bogenlampen (*Z. f. B.*, April 20).
Preisermässigung von Metalldrahtlampen (*Z.f.B*, April 10).

GAS, OIL, AND ACETYLENE LIGHTING.

Alberts. Moderne Strassen- und Geschäftsbeleuchtung (*J. f. G.*, April 19).
Althoff. Anliegerbeiträge für Beleuchtung (*J. f. G.*, May 3).
Kropf, F. Gasbeleuchtung und Photographie (*J. f. G.*, May 10).
Pickhardt, H. Beautifying the Gaslight (*The Gas Industry*, March).
Rosenberg, P. L'Utilisation de l'Acétylène dans l'Armèe (*Rev. des Éclairages*, April 30).
L'Éclairage des Petites Villes ; Electricité ou Acétylène (*Rev. des Éclairages*, April 15).
Artificial Daylight with Gas (*Am. Gaslight Journal*, April 21).
The Ramsay Gas Flashomotor (*G.W.*, April 5).
Un Auxiliaire du Gaz et de l'Electricité (*Moniteur de l'Industrie du Gaz, etc.*, April 15).
Nouvelles Méthodes dÉ'clairages Automatique des Phares, etc. (*Rev. des Éclairages*, March 31).
Die Entwicklung der Oel- und petroleum- beleuchtung (*Licht und Lampe*, April 24).

CONTRACTIONS USED.

E. T. Z.—*Elektrotechnische Zeitschrift.*
Elek. u. Masch.—*Elektrotechnik und Maschinenbau.*
G. W.—*Gas World.*
J. f. G.—*Journal für Gasbeleuchtung.*
J. G. L.—*Journal of Gaslighting.*
T.I.E.S.—*Transactions of the Illuminating Engineering Society (U.S.A.).*
Z. f. B.—*Zeitschrift für Beleuchtungswesen.*

Street Lighting by OSRAMS

Cheap First Cost.

Low Main-tenance Ex-penses.

Full Particulars on request.

The GENERAL ELECTRIC Co., Ltd.

Head Office:
67, Queen Victoria St., London, E.C.

Frontage near the First Avenue Hotel, Holborn, by the light of 600 c.p. Osrams.

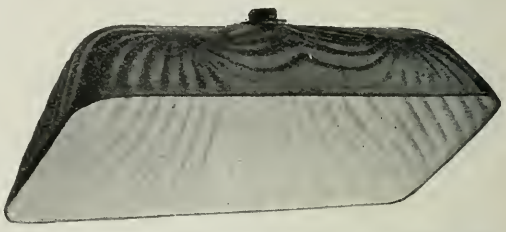
TRADE NOTES.

[At the request of many of our readers we have extended the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

Modern window lighting is decidedly an art. It is now generally agreed that the most artistic effects are secured by using concealed lamps, throwing the light on the goods, but themselves invisible to the eyes of the customer on the pavement, the window being thus illuminated on the same principle as the stage at the theatre.

The question remains how best to concentrate the light on the goods. Obviously this depends on the shape of the window, and the **British Thomson-Houston Co.** (Mazda House, Upper Thames Street, London, E.C.) have evolved two types (shown in the adjacent figures), which are suited to different classes of windows. The reflectors are made of special silvered glass, provided with spiral convolutions designed to eliminate striations and diffuse the light.



B.T.H. X-ray reflector, "Poke-Bonnet" shape to take two lamps. It gives a wide distribution of light, suitable for low deep windows.

B.T.H. X-ray reflector, "Helmet" shape giving a concentrated distribution of light suitable for high and large windows.

Messrs. Siemens Bros. Dynamo Works, Ltd., inform us that they have obtained a contract for the supply of 12,000 "Wotan" lamps for use on the Buenos Aires Great Southern Railway; yet another contract has been secured for the supply of 3,500 of these lamps to the Union of S. Africa.

The **British Westinghouse Electric and Manufacturing Co., Ltd.** (Trafford Park, Manchester), send us a little booklet describing some of their large-power instruments. There is no question that in these days it is well worth while for station engineers and managers of large industrial concerns to watch their power consumption carefully; the booklet indicates how the use of a Westinghouse portable wattmeter will often enable needless losses to be checked and economies made.

Shades of Greatest Utility.

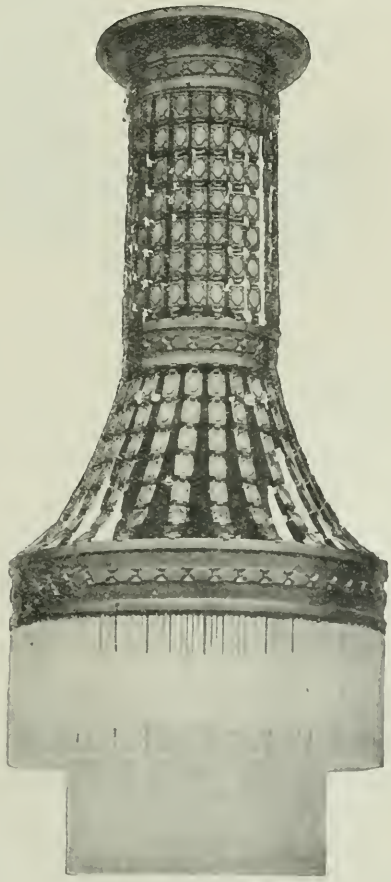
A little booklet issued by **Messrs. Siemens Bros.** describes the application of Wotan lamps and Holophane glassware for the lighting of houses, shops, galleries, and public institutions. Holophane reflector bowls are largely used for illuminating large and imposing interiors, and there are now available various forms of strip and trough reflectors which are just the thing for strongly illuminating a small area.

INDEX, June, 1913.

Subjects.	Authors.	PAGE
Bethnal Green Museum, Lighting of the	An Engineering Correspondent	304
Editorial	L. Gaster	294
Golf Putting Course, Lighting of a	T. J. Little	299
Illuminating Engineering Society :—		
Illuminating Engineering Society :—		
New Members		306
Illumination as a Field for the Optometrist	H. D. Minchin	302
Reviews of Books		342
Review of the Technical Press		345
Semi-Indirect Office Installation, An	An Engineering Correspondent	340
Trade Notes		348
Standard Clauses for Inclusion in a Specification of Street Lighting, Discussion :— Abady, J. (p. 320)—Allen, E. (p. 316)—Bailey, F. (p. 315)—Bradley, J. W. D. (p. 313)—Clark, J. G. (p. 328)—Cooper, W. R. (p. 318)—Darch, J. (p. 315)—Dow, J. S. (p. 329)—Gaster, L. (p. 324)—Goodenough, F. W. (pp. 307, 325)—Pearce, S. L. (p. 327)—Prangnell, N. W. (p. 326)—Ratcliff, H. A. (p. 327)—Trotter, A. P. (p. 329)		
Standard Specification for Street Lighting, Some Notes on.	W. J. Liberty	335

Pharos - Welsbach High-Pressure Gaslight.

We have received from the **Welsbach Light Co., Ltd.** (Welsbach House, King's Cross, London, W.C.), a booklet describing the Pharos-Welsbach system. Particulars of the Welsbach-Bryan Donkin compressors and a variety of outdoor and indoor lamps are given. The illustration shows a highly decorative cover for use with indoor units, and specially recommended for use in public halls, skating rinks, &c. The body is in oxidized copper, and it is supplied with glass fringes, which soften the light from the mantles and avoid glare. This fitting is intended for 2,000, 3,000, and 4,000 c.-p. lamps, and it will be readily understood that some means of softening the light from such powerful sources is often desirable.



The same firm send us a reprint of the letter from Mr. J. C. Van Goetham, recently contributed to *The Gas World*, on the subject of the Manchester Street Lighting. This is entitled 'High-Pressure Gas Lamps *versus* Flame Arc Lamps,' and will doubtless be of interest at the present moment when street lighting is exciting so much attention.

THE

Holophane Lumeter.

The simple, portable, and accurate apparatus for measuring illumination, surface-brightness, or reflecting power.

Can be carried from place to place with the ease of a small hand camera.

Dimensions only $5\frac{3}{4}'' \times 4\frac{1}{2}'' \times 1\frac{3}{4}''$; case and accumulator supplied.

Measurements from 0·01 to 2000 foot-candles can be made.

Showing general appearance of new model of Holophane Lumeter.
(Dimensions : $5\frac{3}{4}'' \times 4\frac{1}{2}'' \times 1\frac{3}{4}''$.)

The Holophane Lumeter is of value not only to lighting engineers, but to architects, medical officers, factory inspectors, photographers, and many others.

Among the users of this instrument may be mentioned :—

The House of Commons, The Home Office (Factory Dept.), The London County Council, General Post Office, Great Western Railway, L. and S.W. Railway, Underground Railways, The Gas Light & Coke Co., St. James and Pall Mall Electric Supply Co., The Union Electric Co., The British Thomson-Houston Co., &c., &c.

For all particulars apply to

HOLOPHANE LTD.

12, Carteret St., Queen Anne's Gate, S.W.

The ILLUMINATING ENGINEER
ELECTRICITY · ACETYLENE · OIL · GAS
Edited by LEON GASTER

THE JOURNAL OF SCIENTIFIC
ILLUMINATION.
OFFICIAL ORGAN OF THE

Illuminating Engineering Society.
(Founded in London, 1909.)

ILLUMINATING ENGINEERING PUBLISHING COMPANY, LTD.

PUBLISHING OFFICES :—ATHENÆUM PRESS 13, BREAM'S BUILDINGS, LONDON, E.C.
Tel. No. 2120 Central.

EDITORIAL OFFICES :—32, VICTORIA STREET, LONDON, S.W.
Tel. No. 5215 Victoria.

EDITORIAL.

The Illuminating Engineering Society.

What It Is and What It Does.

In this number we are publishing the account of the fourth Annual General Meeting of the Illuminating Engineering Society, and the Report of the Council for the past year.

At the present time there should be no need to enlarge on the aims of the Society, which are well known. Readers can obtain full information on this subject by studying the Annual Reports for the last four years.*

But there are two fundamental points specially provided for in the Constitution of the Society that deserve mention: there is, first, the provision of an impartial platform for the discussion of problems of illumination, on which not only engineers interested in various systems of lighting, but other experts (medical men, architects, &c.) can meet and express views. Provision

* See *Ill. Eng.* Lond., vol. ii. 1909, p. 825; vol. iii. 1910, p. 379; vol. iv. 1911, p. 339; vol. v. 1912, p. 299.

has been made for the representation of all these sections on the Council. The idea has been to secure that all illuminants should be adequately represented, but that no one section should prevail; and that, as far as possible, all the various outside experts interested in illumination should take a part.

The experience of the past four years has shown that this aim is entirely practicable. The Council has transacted its business smoothly and pleasantly, and the meetings of the Society have been singularly free from controversial acrimony. There are naturally some points on which gas and electric lighting experts disagree. But it is recognized that there is also a vast field where both can labour and derive benefit.

A second point which impressed those responsible for the starting of the Society was the need for international action. The growth of interest in lighting problems has not been confined to any one country. Illuminating Engineering is still in its infancy. But even at the time the Society was formed tentative rules and recommendations were already crystallizing, and it was evident that unless provision was made for common action there might be inconvenience in the future. Moreover, developments in the field of lighting are so rapid that it is vital for every one to keep in touch with the advances in other countries. The Illuminating Engineering Society decided at an early date to make a special feature of international co-operation, and it has now distinguished Corresponding Members in practically all the chief cities of the Continent and of America.

Another point to be observed is that the Illuminating Engineering Society differs from most purely technical and professional bodies in being in direct touch with the general public. The Society has received distinguished support (a glance at the list of members on pp. 368–86 will confirm this), and may justly claim that the discussions at its meetings have reached a high scientific standard.

Yet at the same time it opens its doors to all who are interested in lighting problems. At present the Society does not insist on definite professional acquirements, and the conditions of membership are simple and easily fulfilled. We are all of us engaged on "a career of self-education," and it is recognized that the experience of the man who *uses* illumination can often make valuable suggestions to the lighting expert.

Moreover, illumination is a subject of such widespread national importance that it can only be treated on wide lines. Literally *every one* is interested in light. It is necessary not merely to train a number of professional experts, but to educate the general public as well.

A feature of the Society's meetings has been the way in which it has fraternized with other bodies only indirectly interested in lighting, and has sought their help and advice when needed. For example, the co-operation of the Library Association was obtained in dealing with library lighting; the Association of Medical Officers in Schools, the Association of Teachers in Technical Institutions, and other bodies took part in the discussion of school lighting. The associations were subsequently represented on the Joint Committee appointed to investigate on these subjects, the interim reports on which appear in this number (see pp. 364–7). The committees are still at work, and their tentative general recommendations will doubtless be supplemented by more detailed suggestions in course of time. But we believe that even if these preliminary suggestions are carried out, a great improvement in school and library lighting throughout the country will result. With the help of the associations represented on the committees, the reports will doubtless receive widespread publicity, and their influence should be very great.

We should like to add that the unanimous agreement of the committees on these reports shows that gas and electrical engineers, as well as outside experts, are willing to work together on matters of illumination. Each clause in the reports was keenly debated; the result is a compromise that should be generally acceptable.

Another instance of such educational work was the issue of the popular series of recommendations on lighting, entitled 'Light and Illumination: their Use and Misuse.' Here, again, the subject-matter was recognized to be applicable both to gas and electric lighting, and two separate editions of the pamphlet have been circulated, having respectively photographs of rooms lighted by gas and electricity, but illustrating the same principles. This publication has been very widely circulated, and has met with an extraordinary amount of attention in the press.

Not the least important section of the work of the Society has been its participation in recent international congresses in Brussels, Paris, Milan, and Turin, where the seed of great future developments has been sown. The movement is developing very rapidly on the Continent, and the need for international co-operation is no longer denied. An Illuminating Engineering Society has now been formed in Germany, and it is hoped that before long there will be a similar society to carry on the good work in France. Recently a very important step has been taken in the formation of a representative Committee in this country to consider the promotion of an International Commission on Illumination.

Wherever we turn we find the subject of illumination forcing

itself upon public attention. At the International Road Congress that has just terminated in London, several important recommendations insisting on the need for improved street illumination were warmly supported. It has just been announced that the National Gas Exhibition to be held this autumn is to receive the patronage of royalty, and illumination will be a special feature.

What is perhaps the crowning recognition of the Society's efforts is the appointment by the Home Secretary of a Departmental Committee on Industrial Illumination. A Committee with similar aims has been established in France, and it is hoped the two countries will exchange information and work together. There can be no question but that the labour of these committees will have a deep influence on the lighting of the future.

Now we ask our readers to remember that all this has been accomplished within the space of four years, with a still comparatively small membership, and an exceedingly moderate subscription. Few societies, we think, could do as much for their members on the present terms.

The cause is one which deserves enthusiasm and support as fully as any now before the public. When one considers the immense benefit to the nation of good lighting, the irreparable harm that may be done to the eyes and health of children in schools and operators in factories by working in defective illumination, and the enormous commercial waste to which faulty conditions of light give rise, one cannot but feel that money spent in researches on this subject would be well repaid.

Many of those who have no direct technical interest in lighting should support this work. But we would point out that the claim on those who are directly connected with the technical side of illumination is infinitely greater. Those who join the Society are brought in touch with the latest developments of the industry, and they are given opportunities of meeting those " in the opposite camp " which they could hardly secure elsewhere. It goes without saying that the lighting industry as a whole will derive immense benefit from this movement, and it is both their duty and their interest to take a share.

The movement has a great future. Something has been achieved, but with adequate support much more might now be done. We therefore urge upon those who already belong to the Society the importance of interesting others in the work and securing a considerably increased membership during the coming session.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society

(FOUNDED IN LONDON, 1909).

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

Annual General Meeting.

[Held at the House of the Royal Society of Arts, London, W.C. on Tuesday, June 3rd, 1913.]

THE Annual General Meeting of the Society took place at the House of the Royal Society of Arts, on Tuesday, June 3rd, 1913, Mr. F. W. Goodenough being in the chair. The minutes of the last meeting having been taken as read, the Hon. Secretary read out the names of new members in the usual way.*

THE CHAIRMAN then called upon the Hon. Secretary to read an abstract of the Annual Report of the Council, which will be found *in extenso* on pp. 357–63.

MR. FRANK BAILEY, in proposing the adoption of the report, pointed out the excellent record of work it contained. All members would be pleased to note the influential position now occupied by the Society, a result which was largely due to the devotion of its officers, who, he might add, laboured in an entirely honorary capacity. They could, therefore, see that the work of the Society had not only been well done, but also very inexpensively done. He had much pleasure in proposing :—

"That the Report of the Council for the session Nov., 1912–May, 1913, be formally adopted."

MR. R. J. WALLIS-JONES briefly seconded the motion, which was declared carried unanimously.

MR. W. C. CLINTON then moved :—

"That this meeting extends a cordial vote of thanks to the Council and officers for their efforts on behalf of the Society during the past session."

No words from him, Mr. Clinton added, were needed to support the motion. They had heard from Mr. Bailey of the great debt which the members owed to the officers of the Society, and he would like to make special reference to the efforts of the Hon. Secretary and the Assistant Hon. Secretary in this connexion. He felt sure that all those present would appreciate the way in which the affairs of the Society had been carried on by the Council during the past year.

MR. J. G. CLARK, in seconding the motion, said that the work of the Society was one of real national importance. The recognition of its value to the community was due largely to the policy pursued by the Council. He had much pleasure in seconding the motion.

The resolution having been carried unanimously, THE CHAIRMAN expressed the thanks of the Council to the members, and added that he wished to associate himself with what had been said with regard to the valuable services of Mr. Gaster and Mr. Dow.

MR. L. GASTER also thanked those present for their kind remarks. They knew that the work done by the officers on behalf of the Society had been a pleasure as well as a labour, and it had been lightened by the fact of having the support of such a harmonious and appreciative Council.

MR. G. DARCH next moved :—

"That this Meeting extends a cordial vote of thanks to the Hon.

* See p. 386.

Auditors of the Society for their services, and that these gentlemen be requested to act in this capacity for another year."

Previous speakers, he remarked, had drawn attention to the fact that the Society was spared many usual expenses, such as salaries, rent for offices, &c., for which members should be very grateful. But he wished to point out that the subscriptions of a considerable number of members were in arrear, and he hoped these members would recognize that it was their obvious duty to pay in their subscriptions without delay.

Mr. J. Wyatt Ife seconded the resolution, which was carried unanimously.

The Chairman then proposed the following resolution :—

"That this Meeting desires to express a cordial Vote of Thanks to the Royal Society of Arts for the courteous permission to make use of the rooms during the past session, and to record its appreciation of the encouragement and support which the Society has received."

The resolution, he said, was one with which, he felt sure, all present would desire to associate themselves.

Mr. Haydn T. Harrison seconded, and the vote of thanks was carried with acclamation.

In conclusion, Mr. R. J. Wallis-Jones said that he had to perform the pleasing duty of asking the members to give a very cordial vote of thanks to their Chairman. Mr. Goodenough was an excellent illustration of the saying that the busy man always has the most time. In spite of pressing work, he had constantly presided over the Council meetings in a most able and courteous manner, and the Society was greatly indebted to him for the attention he had devoted to its affairs.

Mr. O. P. Macfarlane seconded the vote of thanks, remarking that it had been a great pleasure to the Council to have Mr. Goodenough for their Chairman, and the motion was carried with acclamation.

The Chairman briefly expressed his appreciation of these remarks, and the meeting then terminated.

The Jubilee Meeting of the Institution of Gas Engineers.

During the past month the jubilee meeting of the Institution of Gas Engineers has taken place. The occasion was naturally a great one in the history of the gas industry, and a keen appreciation was expressed of the great services of Sir Corbet Woodall, D.Sc., M.Inst.C.E., who presided. A special feature of the proceedings was the presence of delegates from the gas associations in foreign countries. At the Jubilee Dinner, held at the Connaught Rooms on June 18th, many distinguished guests were present, and the evening was a great success.

Our space does not allow us to do more than mention some of the events, and readers may be referred to the usual able summary in the *Journal of Gas Lighting* (June 24th). A phrase in Sir Corbet's address that deserves to be perpetuated was his advice to the industry to make known to the public what gas can do. "Tell the people about it; let them have it at the cheapest rates; *and show them how to use it.*"

This, we take it, will be the object of the great National Gas Exhibition, to take place in the autumn of this year. It was interesting to learn that the King and Queen have graciously consented to patronize the exhibition —truly a striking recognition of the important part played by illumination in the social life of to-day.

Report of the Council for the Session, November, 1912—May, 1913.

[Presented at the Annual Meeting held at the house of the Royal Society of Arts, on Tuesday, June 3rd., at 5.30 P.M.]

In accordance with the usual custom the Council is issuing a Report of Progress during the present session.

A feature of the past year has been the effective co-operation arranged with other societies and institutions, and the establishment of international relations; while the formation of an Illuminating Engineering Society in Germany is an indication that the work so far carried out in this country is appreciated abroad. Our Society is in an exceptionally fortunate position in being able to act as a link between the Continent and America, and as a centre of information on matters connected with illumination; it should therefore be of great service in preparing the way for future international co-operation.

Increased Membership and Support.

A number of influential authorities on the Continent have again joined the Society as Corresponding Members. Among these may be mentioned Dr. Motais, Secretary of the Government Committee on Illumination in France; Dr. J. P. Nuel, Professor at the University of Liège; Dr. C. P. Steinmetz and Dr. Whitney (Schenectady), and Signor F. Massarelli (Milan).

As provided in the constitutions of the Society, three Honorary Members have been nominated during the year: namely, Signor L. Pontiggia, President of the International Congress for the Prevention of Industrial Accidents in Milan (1912); Sir Arthur Whitelegge, Chief Inspector of H.M. Factories in Great Britain; and Prof. Warburg, Director of the Technische Physikalische Reichsanstalt of Charlottenburg and first President of the German Illuminating Engineering Society.

In addition the Council has nominated Dr. R. T. Glazebrook, Director of the National Physical Laboratory, a Vice-President.

The membership of the Society now exceeds four hundred. The following figures will serve to show, roughly, the proportions in which the various interests are represented:—

	Per Cent.
Electrical Engineers and Members concerned mainly with electric lighting	35
Gas Engineers, Manufacturers of Gas Appliances, &c.	19
Professors of Physics and Engineering Experts in Photom try, &c.	12
Representatives of Oil, Acetylene, Petrol Air Gas Lighting, &c.	7
Physicians, Occulists, Opticians, &c. ...	9
Architects, Surveyors, &c.	5
Miscellaneous, including Public Lighting Superintendents, Mechanical Engineers, Makers of Shades and Reflectors, and others not exclusively connected with any one system of lighting	13
	100

The proportions are substantially the same as those presented at the last Annual Meeting. The proportion of electrical engineers has slightly increased. Fuller representation of the gas industry is desirable, and it is hoped that the marked development of interest in the illuminating engineering side of gas lighting will lead to additional members being secured.

Meetings of the Society during the Past Year.

During the past year seven meetings, not including the Annual General Meeting, have been held. The first meeting, on Tuesday, November 19th, was devoted mainly to a summary of progress during the vacation presented by Mr. L. Gaster.* The fact of its

* *Illum. Eng.*, Vol. v., 1912, p. 543.

being found necessary to issue a report of events occurring at this period of the year is surely an excellent indication of the activity of the Society. The remainder of the meeting was given up to a series of short items, including the exhibition of an interesting collection of ancient forms of lamps, kindly shown by Mr. J. W. Johnston.

On December 3rd a paper was presented by Mr. F. W. Willcox, entitled 'Modern Methods of Indirect Lighting,' and at the following meeting, on January 14th, two papers dealing respectively with acetylene and petrol air-gas lighting were delivered by Mr. C. Hoddle and Mr. E. Scott-Snell.

At the next meeting of the Society, on February 18th, a paper entitled 'Some Notes on the Use of Shades and Reflectors,' and dealing with some principles common to all illuminants, was read by Mr. J. G. Clark and Mr. V. H. Mackinney.

Tuesday, March 11th, was devoted to a special lecture by Mr. W. J. Liberty entitled 'The Centenary of Gas Lighting and its Historical Development.' The subject of the lecture was selected in view of the past year being the centenary of gas supply and the present year the jubilee of the Institution of Gas Engineers; a special invitation was issued to the members of this institution to be present, and the attendance was a record. A reprint of the lecture has since been exceptionally widely circulated, and will doubtless do much to spread among the gas industry a knowledge of the work of the Society.

At the last two meetings of the session the time was given up to joint meetings with the Institutions of Gas, Electrical, and Municipal and County Engineers. It will be recalled that a committee, composed of representatives of these institutions and the Illuminating Engineering Society, was formed early in 1911, and has since been engaged in the task of framing a draft specification on Street Lighting. Meantime, Mr. A. P. Trotter had kindly consented to read a paper on 'Street Lighting' before the Illuminating Engineering Society, but the date had been left over in the hope that the report of this committee would be available later in the session. It was subsequently decided to take advantage of the impartial platform of the Society for a general discussion of the principles embodied in the specification—a compliment of which the Society has every reason to feel proud. Permission was accorded to Mr. A. P. Trotter to make use of information brought before the Committee, and much of this was embodied in his paper entitled 'Standard Clauses for Inclusion in a Specification of Street Lighting.'

This paper was presented before a joint meeting of the four societies interested, held in the house of the Royal Society of Arts, on Tuesday, April 15th; owing to the large number of prospective speakers it was decided to resume the discussion at a second meeting on April 29th. The general committee will reconsider the specification, taking into account the views expressed at these two meetings, and it is hoped that this will be the means of suggesting a basis of agreement.

Some Other Papers Read during the Year.

It may be of interest to mention some other events of the year in which members of the Society have been concerned. At the Optical Convention held in London in June an inspiring address was delivered by Prof. Silvanus P. Thompson. A feature of the Convention was the attention given to photometry and illuminating glassware. Shades and reflectors for use with gas and electric illuminants were shown side by side, and polar curves showing the distribution of light were exhibited in each case. Several papers were also presented by members of this Society.

At a meeting of the Royal Society of Arts on February 5th a paper was read by Mr. L. Gaster entitled 'The Economic and Hygienic Value of Good Illumination,' the chair being taken by Sir Arthur Whitelegge. Shortly afterwards Mr. Frank Bailey read a paper before the same Society dealing with the Electricity Supply of London, and the Chairman of the Council (Mr. F. W. Goodenough) has been deliver-

ing a series of Cantor Lectures on the domestic use of gas for fuel.

At a meeting of the Manchester Association of Engineers on January 25th, three papers dealing with the lighting of engineering works by gas, oil, and electricity were read by Mr. Franklin Thorp, Mr. J. E. Evered, and Mr. Haydn T. Harrison respectively (all of whom are members of the Illuminating Engineering Society). The success of the meeting illustrates the practicability of discussing the uses of these rival illuminants amicably on a common platform. An attempt was made to present the papers in such a form as to be comparable one with another. In each case the author was asked to light a workshop of specified dimensions, and the illumination provided, as well as the cost of the respective systems, was mentioned.

The Annual Dinner.

The Annual Dinner took place on February 10th, Prof. Silvanus P. Thompson, F.R.S., being in the chair. The toast of "The Illuminating Engineering Society" was proposed by Mr. Frank Bailey and the President replied with his inimitable felicity. Mr. F. W. Goodenough proposed the toast of "Kindred Societies," and Mr. Duddell (President of the Institution of Elec. Engineers), Mr. Edward Allen (Senior Vice-President of the Institution of Gas Engineers), and Dr. Lawford (President of the Ophthalmological Society) responded. The toast of "The Guests," proposed by the Hon. Secretary, was replied to by Sir Arthur Whitelegge (H.M. Chief Inspector of Factories) and Sir Laurence Gomme (Clerk to the London County Council). The proceedings terminated with the final toast of "The Chairman," proposed by Dr. R. T. Glazebrook, F.R.S.

The attendance showed a considerable increase over that at the dinner in 1912, and the Society was fortunate in securing the presence of such representative and distinguished guests.

Special Committees on School and Library Lighting.

The joint committees on school and library lighting have been continuing their labours. In each case it has been agreed that more detailed and exhaustive inquiries are needed on some of the matters under consideration. The committees, therefore, propose to issue *interim* reports in which the main points already agreed upon are stated in general terms. The committees will continue in existence with a view to presenting subsequently more detailed information, and will continue to act as a permanent centre of information on these subjects.

Lectures on Illumination.

A course of lectures on Illumination has again taken place at the Polytechnic (Regent Street, London, W.), the lecturers being all members of the Society. The fact of the same course being run successfully two years in succession shows there is a steady demand for information on this subject, and it is hoped that courses of this kind will become a regular feature.

'Light and Illumination: their Use and Misuse.'

During the vacation last year the Hon. Secretary paid a visit to the United States, in the course of which he had an opportunity of meeting many prominent members of the American Illuminating Engineering Society, and of arranging for closer co-operation between the two bodies. The enterprising step recently taken in the United States of issuing a small pamphlet summarizing some of the fundamental rules in good lighting had aroused much interest; it was accordingly arranged to prepare a similar pamphlet for distribution in this country so that the proposals emanating from both sides of the Atlantic should be in agreement. A booklet entitled 'Light and Illumination: their Use and Misuse' was prepared by the Editing Committee of the British Society, and was issued early in the present year. The principles are similar to those first advocated in the American publication, the subject-matter being merely slightly modified to suit the conditions in this country. A considerable number of these pamphlets has already been issued, and it

has received an exceptional amount of attention in the press.

The printing, paper, and some of the illustrations have been specially designed. The subject-matter is independent of any illuminant, but arrangements have been made for two editions, having respectively illustrations relating to gas and electricity. The recommendations are of a simple and general character, and it is hoped in the future to supplement them by more detailed suggestions covering special problems in lighting.

The German Illuminating Engineering Society.

The announcement at the commencement of the present session that an Illuminating Engineering Society had been formed in Germany naturally aroused much interest. The Hon. Secretary, while in Berlin last summer, paid a visit to the Reichsanstalt, where, at the request of Dr. Brodhun and Dr. E. Liebenthal, he gave an account of the work of the British Society. Meantime full particulars of the rules and the constitution of our Society had been sent to the Reichsanstalt at the request of Dr. Hagen. This information was naturally of considerable value in suggesting the methods to be followed in forming the Society in Germany, and indicating the lines of future co-operation between the two bodies.

A committee to settle the preliminaries, of which Prof. Warburg (Director of the Reichsanstalt) was the President, and Dr. E. Liebenthal, Secretary, was next formed. The committee also received assistance from Herr Dettmar (Secretary of the Verband deutscher Elektrotechniker) and Dr. Bunte (Secretary of the Verein für Gas und Wasserfachmänner).

The first meeting of the Society took place on February 25th, when an address was delivered by the President and a lecture on 'Illumination and the Eye,' by Prof. Dr. O. Lummer. At this date the Society had already enrolled over 200 members, many of whom are Corresponding Members of our own Society.

A telegram was dispatched to Prof. Warburg, expressing the good wishes of the British Society, and received a cordial acknowledgment. The need for an Illuminating Engineering Society to represent the views of those interested in this subject in Germany, and to provide for international co-operation, is evident. The Society is fortunate in having behind it the influential support of the Reichsanstalt, and with this encouragement its prosperity should be assured.

Annual Congresses and Exhibitions.

In the 'Report of Progress during the Vacation' an account was given of the important Congress for the Prevention of Industrial Accidents, held in Milan at the end of May, 1912.

At this Congress the Hon. Secretary was present as a representative of the Society, and read a paper on the Value of Good Illumination as a Means of Preventing Accidents. The Congress was under the patronage of the King of Italy, and received Government support, about 450 delegates and members being present. There is every reason to hope that the visit will lead to useful results.

During Whitsun week of the present year an Annual Congress of the Royal Institute of Public Health was held in Paris. A special discussion, entitled 'Lighting as a Health Factor in Occupation, and its Influence on the Prevention of Accidents,' was opened by Mr. L. Gaster on behalf of the Illuminating Engineering Society. This section was presided over by Sir Thomas Oliver, and provided a valuable opportunity of interesting medical men in the illuminating engineering movement.

It may also be mentioned that illumination is to be a special feature at the National Gas Exhibition, to be held at Shepherd's Bush during the present year. The assistance of the Illuminating Engineering Society has been invited, and it is hoped to make full use of this occasion to interest the general public in illumination, and to provide practical examples of good lighting.

The Illumination of Mines and Miners' Nystagmus.

A brief reference may be made to the question of illumination in mines, referred to in the 'Report of Progress during the Vacation.'

Medical authorities have been concerned by the development in certain mines of a nervous disease of the eyes —nystagmus. The matter was referred to at the Brussels Congress in 1910, and was also mentioned in a question addressed to the Home Secretary by Mr. Arthur Lynch in the House of Commons last year. From researches carried out by Dr. T. L. Llewellyn, Dr. Elworthy, and others there appears good ground for believing that the disease is due largely to defective illumination. Good lighting in mines is also essential in the interests of safety. These considerations led the Home Office recently to offer prizes to the value of £1,000 for the best form of miners' lamp, and some lamps awarded prizes in this competition were shown at the opening meeting. Similar competitions, with a view to improving miners' lamps, have been organized on the Continent.

The Departmental Committee on Industrial Illumination.

In the Annual Report for 1911 special reference was made to the important step taken by the French Committee in appointing a committee on the 'Hygienic Aspects of Illumination,' and the hope was expressed that a similar committee would be established in this country. During the past year this committee has been appointed by the Home Secretary, and is already actively at work. Its functions are :—

> "To inquire and report as to the conditions necessary for the adequate and suitable lighting (natural and artificial) of factories and workshops, having regard to the nature of the work carried on, the protection of the eyesight of the persons employed, and the various forms of illumination."

The members of the Committee are as follows :—

Dr. R. T. Glazebrook, C.B., F.R.S., Director of the National Physical Laboratory (Chairman); Mr. Leon Gaster; Prof. Francis Gotch, D.Sc., F.R.S.; Mr. J. Herbert Parsons, M.B., D.Sc., F.R.C.S.; Mr. W. C. D. Whetham, F.R.S.; and Sir Arthur Whitelegge, K.C.B., Chief Inspector of Factories.

The Secretaries of the Commission are :—

Mr. D. R. Wilson, one of H.M. Inspectors of Factories, and Mr. C. G. Paterson, M.I.M.E., A.M.I.C.E., of the National Physical Laboratory."

The Report of H.M. Chief Inspector of Factories for 1911, issued shortly after the last Annual Meeting, contained a most interesting section devoted entirely to industrial lighting and occupying 38 pages (about 12 per cent of the total space of the report). The chief feature of this section is the exhaustive series of tests of illumination carried out by Mr. D. R. Wilson, over 2,500 measurements of illumination, made in 125 different factories.*

Meantime other countries have been active. In the United States the New York Factory Commission has adopted an amendment of the existing act relating to factories, and a series of recommendations has been inserted requiring good illumination in general terms. The Act is to take effect on October 1st, 1913.†

The Académie Royale de Médicine in Belgium has likewise taken the matter up. An important communication was put forward by Dr. Motais, the Secretary of the French Commission on Illumination, at a meeting on December 7th, 1912. In recapitulating the circumstances leading to the formation of the committee in France, Dr. Motais laid stress on the desirability of creating a similar committee in Belgium. The following resolution was put to the vote and carried unanimously :—

> "That the Academie de Médicine having heard the views of Prof. Motais (Angers), speaking in the name of the Committee on Natural and Artificial Illumination in France

* *Illum. Eng.*, Lond. vol. v., 1912, pp. 382-84, 418-22.

† *Illum. Eng.*, Lond. Jan. 1913, p. 16.

in his capacity as general secretary of this committee, expressed the desire that the Belgian Government should follow the example of the French Government, and several other foreign governments, and nominate an official committee charged with the study of all questions bearing on natural and artificial illumination and the hygiene of vision."*

It may be hoped that committees dealing with industrial lighting will ultimately be formed in all the chief European countries. Co-operation between these committees would be desirable, so that they may be in a position to present definite proposals at an international congress on illumination. In this way general recommendations on lighting, applicable all the world over, might gradually be evolved.

Financial Position of the Society.

The balance-sheet, showing the income and expenditure during 1912, indicates that a distinct improvement has taken place over the previous year. The Society has again been able to carry out a considerable amount of useful work, and yet to keep its expenditure within bounds. The circumstances that render this possible were detailed in the Annual Report for 1912–13 †

The arrangement by which *The Illuminating Engineer* acts as the official organ enables the Society to publish its transactions, the cost of which would otherwise be prohibitive. The Society has also been fortunate in not being called upon to meet many customary expenses, such as rent of offices, secretary's salary, &c., and its officers, in an honorary capacity, have ungrudgingly devoted much time to its affairs.

At the same time the growing activities of the Society make the present arrangement somewhat burdensome, and its future work may be hampered unless more ample funds can be placed at its disposal. A substantial increase in membership is still necessary in order that the Society may be entirely self-supporting with its present moderate subscription, and the Council desire to emphasize the importance of securing additional members. The Council also desire to point out that in accordance with Article 23 in the constitution of the Society "any member may commute or compound for all future payments and become a member for life, by payment of a sum of not less than £10 10*s*. (ten guineas)." It is hoped that a number of members will take advantage of this method in order to provide additional present income, and enable the Society to extend the scope of its operations in the near future. The Society has now a record of valuable work behind it, and its usefulness is beyond dispute. It has therefore a right to expect that those who benefit by the movement will give their aid, and enable it to extend its present sphere of work.

Programme for the Next Session.

The Council is now engaged in considering the programme for the next session. Members who are willing to read papers are invited to notify the Hon. Secretary as soon as possible, and to send in contributions early in the vacation.

A list of suitable subjects (which, however, is not regarded as exhaustive), will be found in the Appendix.

The Council take this opportunity of inviting any further suggestions as to the future work of the Society, or any subjects which might receive special attention during the next session.

By Order of the Council,
Leon Gaster,
Hon. Secretary

* *Illum. Eng.*, Lond., vol. vi., Jan. 1913, p. 17.

† *Illum. Eng.*, Lond. vol. v., 1912, p. 305.

APPENDIX.

List of Suggested Subjects on which Papers are invited.

1. The nomenclature and terminology of illuminating engineering.
2. New forms of instruments for measuring light and illumination and new apparatus for use in the photometrical laboratory. Methods of testing colour. Methods of testing the steadiness of sources of light.
3. Fixture design: the compromise between artistic and illuminating principles.
4. Decorative lighting and illuminating engineering from the standpoint of artistic effect and architectural principles.
5. The measurement of daylight and its application by the architect to designing window-space, and the access of natural light to interiors. The value of photometry in deciding ancient light cases.
6. Simple methods of calculating beforehand the distribution and intensity of illumination in interiors.
7. Instruction in illuminating engineering: Courses of lectures and laboratory work, &c.
8. The benefits of good illumination from the insurance standpoint, and as a means of preventing accidents.
9. Specific problems in the lighting of factories and workshops.
10. Illumination and portable safety lamps for mines, &c.
11. Modern methods of lighting and illuminants employed in ships, lighthouses, buoys, coast-lights, beacons, &c.
12. The use of light for advertising purposes, illuminated signs and devices, illuminated placards, billboards, notices, &c.
13. The production of light of various colours, and the best means of modifying the spectra of artificial illuminants so as to resemble that of daylight.
14. Problems encountered in the lighting of museums, picture galleries. &c.
15. The decorative lighting of parks, avenues, and flower gardens, fêtes, &c.
16. The physiological aspects of illumination, and the effects of artificial light on the eyes.
17. The correct application of light in projection, searchlights, lanterns, cinematographs, &c.
18. The lighting of billiard tables.
19. The artificial illumination of athletic grounds, tennis courts, skating rinks, bowling alleys, &c.
20. Country house lighting by private electrical installations, by acetylene, or by petrol air-gas and incandescent oil vapour.
21. Theatre lighting: Illumination on the stage and its use to produce scenic effects, &c.

ERRATUM. We note that in the contribution from Mr. Liberty, published in our last number, the illustrations (Figs. 3 and 4) on p. 337 representing the lighting of Cannon Street and Queen Victoria Street respectively, were inadvertedly interchanged.

The Artificial Lighting of Schools.

[Preliminary Report of the Joint Committee appointed in 1911; issued by the Illuminating Engineering Society with the approval of the delegates of the Associations represented on this committee.]

Members of Committee.

Prof. W. C. Clinton, Mr. J. Darch, Dr. W. Ettles, Mr. F. W. Goodenough, Dr. H. R. B. Hickman, Dr. J. Kerr (*chairman*), Mr. W. R. Rawlings, Mr. T. E. Ritchie, Mr. A. Stokes, Mr. S. E. Thornton, Mr. P. J. Waldram, Mr. R. J. Wallis-Jones representing the Illuminating Engineering Society.

Dr. R. S. Clay, representing the Association of Technical Institutions.

Dr. J. H. Vincent, representing the Association of Teachers in Technical Institutions.

Mr. E. S. Mortimer, representing the London Teachers' Association.

Dr. E. H. Nash, representing the Medical Officers of Schools Association.

Dr. N. Bishop Harman.

Ex-officio.

The President (Prof. S. P. Thompson), Hon. Secretary (Mr. L. Gaster), and Assistant Secretary (Mr. J. S. Dow), of the Illuminating Engineering Society.

This Committee was appointed in 1911, following the discussion of the papers on 'Natural and Artificial Illumination of School-Rooms,' read before the Illuminating Engineering Society by Dr. J. Kerr and Dr. N. Bishop Harman in that year. The first meeting of the Committee took place on March 7th, 1912, when a list of subjects for consideration was drawn up. The terms of reference of the Committee included both daylight and artificial illumination, but it was resolved that the latter subject should be dealt with first. There are a number of investigations which still remain to be pursued in detail, but it was considered that the time was ripe to issue an interim report embodying the conclusions so far reached.

Intensity of Illumination Required.

The intensity of illumination necessary in school-rooms depends on the nature of the work carried out. In many details further experience is necessary before precise limits can be assigned to these quantities in specific cases.

A distinction might be drawn between the needs of children and the requirements of adults. But inasmuch as the results of working by defective illumination seem likely to be proportionately more serious in the case of children, the Committee have considered mainly their needs in making these suggestions. A broad distinction should also be drawn between ordinary clerical work (reading and writing, &c.), and special work (art and metal work, embroidery, &c.). A number of experiments on this point were conducted by the Committee, the illumination being adjusted until it appeared sufficient for various classes of work, and photometric measurements then made.

As a result it is suggested that (*a*) for ordinary clerical work (reading and writing, &c.), the minimum illumination measured at any desk where the light is required, should not fall below 2 foot-candles.* (*b*) For special work (art classes, drawing offices, workshops, and stitching with dark materials, &c.), a minimum of 4 foot-candles is desirable. (*c*) For assembly rooms, &c., and for general illumination a minimum of 1 foot-candle measured on a horizontal plane 3 ft. 3 in. from the ground. The question of the permissible diversity factor remains to be considered.

It was also recommended in view of the general recognition of the prejudicial effect on the eyes of children of fine needlework carried on by artificial light, that only coarse work on white material should be executed by

* Four members of the Committee, Mr. Goodenough, Mr. Stokes, Mr. Darch, and Mr. Mortimer, were strongly of opinion that the minimum illumination should not be less than 2½-foot-candles.

artificial light in elementary schools; the minimum in this case being the same as for (*a*) above.

Direct, Indirect, and Semi - Indirect Lighting.

The Committee then proceeded to consider various methods of lighting school-rooms. A series of questions relating to the respective merits of direct, indirect, and semi-indirect lighting were drawn up and submitted to Mr. J. G. Clark, Mr. V. H. Mackinney, Mr. T. E. Ritchie, and Mr. F. W. Willcox. The thanks of the Committee are due to these gentlemen for the trouble they have taken in preparing answers to these questions and attending before the Committee to state their views.

After hearing this evidence the Committee took note of the respective advantages of these methods for certain classes of work but decided that the above standards of illumination should be provisionally adopted irrespective of the method of lighting.

Blackboard Lighting.

The question of blackboard lighting was next considered. Whereas the minimum illumination suggested for reading purposes (namely 2 foot-candles) might be enough in the case of a small class-room, where white chalk is mainly used, and no students are further than 20 feet from the blackboard, a higher value would in general be necessary in the case of larger rooms, and on boards where it is customary to use diagrams in coloured chalk. By the kind permission of Dr. R. S. Clay a number of experiments on this point were carried out at the Northern Polytechnic the blackboard being illuminated with varying intensities, and the visibility of figures written in white and coloured chalks examined from various parts of the room. As a result the Committeee recommend that an illumination on the blackboard about 60 per cent in excess of that prevailing in the rest of the room is desirable.

As a rule it would be necessary for the illumination on the blackboard to be carried out by special local lighting from lamps equipped with opaque screens, completely concealing them from the eyes of students. The nature of the surface of the blackboard is also of importance. This should be maintained a dead black sensibly free from regular reflection, so that the maximum contrast between the white chalk and the blackboard may be available, and that there may be no glare due to reflection from polished surfaces. The blackboard should be repainted at regular intervals.

Avoidance of Glare.

A point of special importance in connexion with school-room lighting is the avoidance of glare from the sources of light, and the Committee desire to emphasize the value of proper methods of shading. It is a common defect in school-rooms for the bare mantles or filaments to be within the range of vision of students when looking towards the blackboard. The Committee recommend that no lamps should come within the solid angle sub-tended at the eye by the blackboard and a space two feet above it, unless they are completely screened from the eye by a shade impervious to light. In general it is desirable that no incandescent surface should be visible to the eyes of students or teachers, while carrying on their ordinary work.

Another source of glare is the direct reflection of light from the polished surfaces of the desks or paper. It would be desirable for textbooks intended for the use of young children to be printed on matt paper that is sensibly free from prejudicial reflection of this kind.

As a further means of avoiding this defect the Committee advocate the the use of shades in which the brightness of the source is spread out over a considerable area, and the judicious use of reflection from the walls and ceilings of the room. These should be of such a texture that any considerable regular reflection is avoided, glazed and shining surfaces above the dado being specially objectionable.

Avoidance of Inconvenient Shadows.

In the class-room the lights should be so arranged that inconvenient shadows cast by the body on the desk should be as far as possible avoided. The precautions suggested under the previous heading and particularly the use of light-tinted surroundings which serve to diffuse the light, may be recommended with a view to softening the shadow. The ceilings should be preferably of a warm white colour, and the walls and all woodwork above the dado should be light in tint.

Conclusion.

The Committee offer the above tentative suggestions as a preliminary to more detailed recommendations.

Through the courtesy of Mr. Blair and the Education Department of the London County Council, several school-rooms lighted respectively by gas and electricity have been placed at the disposal of the Committee. A number of experiments have already been conducted with a view to demonstrating to the satisfaction of the Committee that the present recommendations are practicable, and this report was finally reconsidered after the Committee had paid a visit of inspection of the rooms in question.

The wider aspects of artificial illumination and the subject of daylight illumination are being considered, and the Committee propose to report on this subject at a later stage.

By Order of the Council,
LEON GASTER,
Hon. Secretary.

The Artificial Lighting of Libraries.

[Preliminary Report of the Joint Committee appointed in 1911. Issued by the Illuminating Engineering Society, with the approval of the Library Association.]

MEMBERS OF THE COMMITTEE.

Representing the Illuminating Engineering Society.—Dr. W. M. Bayliss, Mr. J. G. Clark, Mr. J. Eck, Mr. S. Hamp, Mr. Haydn T. Harrison, Mr. Chas. W. Hastings, Mr. B. H. Jenkinson, Mr. V. H. Mackinney, Mr. N. W. Prangnell, and Mr. A. P. Trotter (Chairman).

Representing the Library Association.—Mr. H. Bond, Mr. J. Duff Brown, Mr. B. Carter, Mr. Hopwood, Mr. H. Jones, Mr. R. Peddie, and Mr. H. R. Tedder.

Ex-Officio. — The President, Hon. Secretary, and Asst. Hon. Secretary of the Illuminating Engineering Society.

The terms of reference of the Committee include both natural and artificial lighting, but it has so far confined itself only to the latter.

The first meeting was held on March 14th, 1912, when a list of subjects for consideration was drawn up, and these have been subsequently discussed in detail.

The Committee feel it would not be desirable to report definitely on many of these points at the present moment, owing to the developments constantly taking place in methods of illumination and the necessity of fuller information as to their respective merits. It was therefore decided to issue an interim report embodying the points on which agreement has so far been reached.

AMOUNT OF ILLUMINATION DESIRABLE.

The first question which received the Committee's notice was the amount of illumination required. A distinction should here be drawn between the conditions requisite for various classes of libraries, but the following tentative recommendations seem to have a general application, and are in accordance with experience of the conditions met with in a large number of libraries in London.

(1) *Table, desk, or newspaper stand lighting.*—The illumination where the light is being used should in no case be less than 2 foot-candles. This

value is understood to apply to reading ordinary type printed on white paper. When books printed in small type, or manuscripts, or surfaces having a low reflecting power are to be studied, a higher illumination is necessary, and a tentative value of not less than 5 foot-candles is suggested.

(2) *Book-case and shelf-lighting.*—A minimum vertical illumination on the case or shelf of $\frac{1}{2}$ foot-candle.

(3) *General Illumination.*—A minimum of $\frac{1}{5}$ foot-candle. Local illumination should be measured on the desk, slope, or table, where reading is carried on. Measurements of general illumination should be made on a horizontal surface, 3 ft. 3 in. above the ground. In all cases the illumination to be expressed in foot-candles.

Avoidance of Glare.

The Committee desire to emphasize the importance of adequate methods of shading with a view to avoiding glare from illuminants such as is apt to be trying to the eyes of readers. It is proposed to deal with this point more specifically shortly. Meantime, it is suggested that the light source (*e.g.*, the filament of an electric lamp or an incandescent gas mantle) should not be visible to the reader.

Avoidance of Reflection from the Surface of Paper or Tables.

One of the disadvantages of arranging lights close to a reader is the production of troublesome reflections from the glazed paper or from the tables. The position of lights should therefore be selected in such a manner that no rays are reflected *directly* off the polished surface of the paper into the eyes. It is also desirable, as a means of minimizing this defect, that the source of light should be extended over a considerable area (either by means of suitable methods of screening, or by making use of the reflection of lights from white or light-tinted walls and ceiling).

Avoidance of Shadows.

Harmful shadows, particularly those thrown by the readers themselves, should be avoided by suitable arrangement of the lights. The methods suggested under heading (4) are also useful with a view to preventing this defect. Since sharp shadows are cast mainly by direct rays from sources of light of small area, the desirability of making judicious use of the reflection from light-tinted surroundings is indicated. In general it is preferable to avoid materials which are very dark in colour and absorb a great deal of light. Shadows are apt to be cast by the heads of readers examining shelves; with a view to avoiding this, local shelf lighting by well-shaded lamps is sometimes desirable.

The Committee do not at present desire to recommend definitely any particular system of lighting for libraries, recognizing that the purpose for which the library is intended (*e.g.* whether as a reference library for casual reading or for lending books, &c.), must be considered. Local lighting and general lighting have both their respective merits, but in general a combination of the two methods is most advantageous. The comparative advantages of direct, indirect, and semi-indirect lighting are being considered, and the question of the best means of illuminating racks and shelves is also receiving attention. The Committee will continue to act as a centre for information on these subjects. It is proposed to supplement this interim report by a series of more detailed recommendations, and also by some suggestions as regards daylight illumination.

By Order of the Council,
Leon Gaster,
Hon. Secretary.

The Illuminating Engineering Society.

(FOUNDED IN LONDON, 1909.)

LIST OF OFFICERS AND MEMBERS.

PRESIDENT.

PROF. SILVANUS P. THOMPSON, D.Sc., F.R.S., Past President of the Inst. of Electrical Engineers, Professor of Electrical Engineering and Principal of the City and Guilds of London Technical College, Finsbury, E.C., "Morland," Chislett Road, W. Hampstead, LONDON, N.W.

VICE-PRESIDENTS.

SIR WILLIAM ABNEY, C.B., D.Sc., F.R.S., Adviser to the Board of Education, Member of Advisory Council for Education to the War Office (1903), late President of the Royal Astronomical Society, Physical Society, &c., Rathmore Lodge, South Bolton Gardens, LONDON, S.W.

DR. LOUIS BELL, Consulting Electrical Engineer of the Edison Electric Illuminating Co., 120, Boylston Street, BOSTON, U.S.A.

PROF. A. BLONDEL, Professor of Electrical Engineering, Chief Engineer of the Lighthouse Service, France, 41, Avenue de la Bourdonnais, PARIS.

SIR JAMES CRICHTON BROWNE, F.R.S., Vice-President and Treasurer of the Royal Institution, &c., Grindau, Dumfries, SCOTLAND.

DR. E. BUDDE, Professor of Electrical Engineering, President of the International Electrotechnical Commission, President of the Verband Deutscher Elektrotechniker, Berlinerstr. 54, CHARLOTTENBURG, Germany.

PROF. H. BUNTE, Ph.D., Professor at the Technische Hochschule, KARLSRUHE, Gen. Secretary of the Verein von Gas- und Wasserfachmännern, Editor of the *Journal für Gasbeleuchtung*.

SIR WM. CROOKES, F.R.S., M.I.E.E., &c., Past President of the Inst. of Electrical Engineers, Chem. Soc., British Assoc., &c., 7, Kensington Park Gardens, LONDON, W.

PROF. H. DREHSCHMIDT, Chief Chemist of the Municipal Gas Works, Tegel, BERLIN.

E. L. ELLIOTT, New York, one of the founders of the Illuminating Engineering Society in the United States, 15, West 38th Street, NEW YORK, U.S.A.

DR A. H. ELLIOTT, Chief Chemist and Director of the Consolidated Gas Co., Chairman of New York Section of the Illuminating Engineering Society (U.S.A.) in 1910, 165, Broadway, NEW YORK.

PROF. J. A. FLEMING, D.Sc., F.R.S., M.I.E.E., &c., Professor of Electrical Engineering at University College, Gower Street, LONDON.

W. H. GARTLEY, Chief Engineer of Philadelphia Gas Works, Past Vice-President of the American Gas Institute, Past President of the Illuminating Engineering Society (U.S.A.), 1401, Arch Street, PHILADELPHIA.

DR. R. T. GLAZEBROOK, F.R.S., Director of the National Physical Laboratory, Teddington, ENGLAND.

DR. J. S. HALDANE, F.R.S., Professor of Physiology at Oxford University, Gas Referee, &c.

DR. A. E. KENNELLY, President of the American Illuminating Engineering Society (1911), Professor of Electrical Engineering, Harvard University, Cambridge, MASS., U.S.A.

DR. H. KRÜSS, Manufacturer of Optical and Photometrical Apparatus, Chairman of the Photometrical Committee of the Verein von Gas- und Wasserfachmännern, 6, Adolphsbrucke, HAMBURG, Germany.

V. R. LANSINGH, President of the Illuminating Engineering Society (U.S.A.), 29, West 39th Street, NEW YORK, U.S.A.

F. LAPORTE, Civil and Mining Engineer, Assistant Director of the *Laboratoire Central d'Electricité*, 12 and 14, Rue de Stael, PARIS.

PROF. VIVIAN LEWES, Mem. Inst. Gas Engrs., Lecturer at the Royal Naval College, Greenwich, City Gas Examiner, &c., 30, Crooms Hill, Greenwich, LONDON, S.E.

PROF. O. LUMMER, Co-Inventor of the Lummer-Brodhun Photometer, The University of Breslau, GERMANY.

L. B. MARKS, Consulting Engineer, First President of the Illuminating Engineering Society (U.S.A.), 103, Park Avenue, NEW YORK, U.S.A.

W. M. MORDEY, M.I.E.E., Past President of the Institution of Electrical Engineers, 82, Victoria Street, London, S.W.

DR. J. H. PARSONS, F.R.C.S., &c., Ophthalmic Surgeon, Lecturer at University College, &c., 54, Queen Anne's Street, Cavendish Square, London, W.

SIR WM. PREECE, K.C.B., F.R.S., &c., Consulting Electrical Engineer, Past President of the Institutions of Electrical and Civil Engineers, Penrhos, Carnarvon, NORTH WALES.

SIR BOVERTON REDWOOD, D.Sc., F.R.S.E., F.I.C., Consulting Chemist, Adviser on Petroleum to the Home Office, &c., 4, Bishopsgate Street, Within, LONDON, E.C.

DR. C. H. SHARP, Past President of the Illuminating Engineering Society (N.Y.), Chief of the Electrical Testing Laboratories, 80th Street, East End Avenue, NEW YORK, U.S.A.

L. A. STOKES, F.R.I.B.A., President of the Royal Institute of British Architects, 2, Great Smith Street, LONDON, S.W.

PROF. J. TEICHMÜLLER, Ph.D., Consulting Electrical Engineer and Professor of Electrical Engineering, Member of the Photometrical Commission of the Verband Deutscher Elektrotechniker (1909), Nowackanlage 2, KARLSRUHE, Germany.

PROF. ELIHU THOMSON, Past-President of the International Electrotechnical Commission, President of the General Electric Co., West Lynn, MASS., U.S.A.

A. P. TROTTER, M.I.E.E., Electrical Adviser to the Board of Trade, 8, Richmond Terrace, Whitehall, LONDON, S.W.

PROF. UBBELOHDE, Ph.D., Gen. Secretary of the International Petroleum Commission, Tech. Hochschule, KARLSRUHE, Germany.

PROF. DR. ULBRICHT, President of the Königl. Generaldirektion der Sächsischen Staatsbahnen, Member of the Photometrical Commission of the Verband Deutscher Elektrotechniker, 3, Hettner Str. DRESDEN.

PROF. J. VIOLLE, Inventor of the Violle Standard of Light, 89, Boulevard Saint Michel, PARIS.

PROF. L. WEBER, Professor of Physics at the University of Kiel, Moltkestrasse 60, KIEL, Germany.

PROF. DR. W. WEDDING, Professor at the Technische Hochschule Charlottenburg, Gross Lichterfelde, Wilhelmstrasse 2, BERLIN.

SIR HENRY TRUEMAN WOOD, Secretary of the Royal Society of Arts, John Street, Adelphi, LONDON.

HONORARY LIFE MEMBERS.

Moeller, Dr. A., President of the Academie Royale de Médecine, Member of the Commission des Accidents du Travail, 1, Rue Montoyer, BRUSSELS.

In recognition of valuable services as President of the Congrès International des Maladies Professionnelles, Brussels, 1910.

Pontiggia, Sig. Luigi, Directeur de l'Associazione degli Industrali d'Italia per prevenire gli infortuni del lavoro, 4, Piazza Cavour, MILAN.

In recognition of valuable services as President of the First International Congress for the Prevention of Industrial Accidents held in Milan, May, 1912.

Preece, Sir William, *K.C.B., F.R.S., &c.* Consulting Electrical Engineer, Past President of the Institutions of Electrical and Civil Engineers, Penrhos, Caernarvon, N. WALES.

In recognition of valuable pioneering work in connexion with the measurement of illumination.

Swan, Sir Joseph, *M.A., F.R.S., D.Sc., &c.* Past President of the Institution of Electrical Engineers, &c., Overhill, WARLINGHAM, Surrey.

In recognition of valuable services in connexion with electric lighting, and as one of the inventors of electrical incandescent lamps.

Thompson, Prof. Silvanus P., *D.Sc., F.R.S.* Past President of the Inst. of Electrical Engineers, Professor of Electrical Engineering and Principal of the City and Guilds of London Technical College, Finsbury, E.C., "Morland," Chislett Road, West Hampstead, LONDON, N.W.

In recognition of valuable services as President of the Illuminating Engineering Society during its first two years of existence.

Vernon Harcourt, Prof. A. G., *M.A., F.R.S.* Past President of the Chemical Society, Metropolitan Gas Referee, &c., St. Clare, RYDE, Isle of Wight.

In recognition of valuable services in connexion with photometry and the invention of standards of light.

Warburg, Prof. Dr., Director of the Technische Physikalische Reichsanstalt, Charlottenburg, BERLIN.

In recognition of distinguished services as Director of the Reichsanstalt and as the First President of the German Illuminating Engineering Society.

Whitelegge, Sir Arthur, K.C.B. H.M. Chief Inspector of Factories, Whitehall, LONDON, S.W.

In recognition of valuable services in promoting the study of industrial illumination.

MEMBERS OF THE COUNCIL.

CHAIRMAN.

F. W. Goodenough, Mem. Inst. Gas Engrs., Sales Controller of the Gas Light and Coke Co., Horseferry Road, London, S.W

E. Allen, President Elect of the Institution of Gas Engineers, Liverpool United Gas Co., 4, Duke Street, Liverpool.

F. Bailey, Chief Engineer, City of London Electric Lighting Co., Ltd., 64, Bankside, London, S.E.

Prof. W. M. Bayliss, M.A., D.Sc., F.R.S., Assistant Professor of Physiology at University College, London, St. Cuthbert's, Hampstead Heath, London.

F. J. Cox, M.I.M.E., Consulting Engineer to the Machine Gas, Ltd., 212, Brecknock Road Tufnell Park, London, N.

J. Darch, F.S.I., Surveyor, Mem. Roy. San. Inst., 55, West Side, Wandsworth Common, London, S.W.

J. S. Dow, Asst. Editor of *The Illuminating Engineer*, Mayfield, Shepherd's Hill, Highgate, London.

J. Eck, M.I.E.E., Manager and Chief Engineer of the Union Electric Co., Park Street, Southwark, London, S.E.

L. Gaster, Consulting Engineer and Editor of *The Illuminating Engineer*, &c., 32, Victoria Street, London. S.W.

Haydn T. Harrison, M.I.E.E., Electrical Engineer, 11, Victoria Street, London.

C. W. Hastings, Mem. Inst. Gas Engrs., Editor of *The Gas Engineer's Magazine*, 5, Trinity Road, Wimbledon, England.

Dr. H. R. B. Hickman, M.A., M.B.(*Oxon*), M.R.C.S., L.R.C.P., Ophthalmic Surgeon, 5, Harley Street, London, W., and White Hill House, Chesham, Bucks, England.

J. Wyatt Ife, Lighting Engineer, 12, Carteret Street, London, S.W.

Col. W. F. Leese, Director of Brompton Electricity Co., The Costa Rica, and the Rosario Electric Cos., &c., 17, Carlton Road, Ealing.

F. A. Cortez Leigh, Chief Electrical Engineer, London and North-Western Railway, Euston Station, London, N.W.

Dr. R. Lessing, Ph.D., F.C.S., Consulting and Analytical Chemist, Southampton House, 317, High Holborn, London.

Dr. A. H. Levy, M.D., F.R.C.S., &c., Ophthalmic Surgeon, Central London Ophthalmic Hospital, &c., 67, Wimpole Street, Cavendish Square, London, W.

O. P. Macfarlane, Manager of the Gas Economizing and Improved Light Syndicate, Ltd., 35, King's Avenue, Muswell Hill, London, N.

S. L. Pearce, M.Inst.C.E., M.I.E.E., &c., Chief Electrical Engineer to the Manchester Corporation, Dickinson Street, Manchester, Past President of the Incorporated Municipal Electrical Association.

W. R. Rawlings, Electrical Contracting Engineer, Past-President of the Electrical Contractors' Association, 82, Gloucester Road, South Kensington, London, S.W.

E. Scott-Snell, Director of County Light, Ltd., Guildford Street, London, S.E.

A. Stokes, Chief Outdoor Inspector of the South Metropolitan Gas Company, 709, Old Kent Road, London.

S. E. Thornton, Chairman of Messrs. W. Sugg & Co., Sanctuary House, Tothill Street, London, S.W.

A. P. TROTTER, M.I.E.E., Electrical Adviser to the Board of Trade, 8, Richmond Terrace, Whitehall, London, S.W.

P. J. WALDRAM, F.S.I., Surveyor and Civil Engineer, 12, Buckingham Street, Charing Cross, London, W.C.

R. J. WALLIS-JONES, M.Inst.C.E., M.I.E.E., Consulting Electrical Engineer, 50, Queen Anne's Gate, Westminster, London, S.W.

Hon. Secretary—L. GASTER.

Secretary—J. S. DOW.

Hon. Treasurer—J. WYATT IFE.

Hon. Solicitors—MESSRS. G. M. LIGHT & FULTON, 1, Laurence Pountney Hill, Cannon Street, London, E.C.

LIST OF MEMBERS OF ALL CLASSES (June, 1913).

[*The figure at the end of the address denotes the quarter day upon which the subscription becomes due. Thus* (1) *denotes Jan. 1st;* (2) *April 1st;* (3) *July 1st, and* (4) *Oct. 1st respectively.*]

V.P.—Vice-President. **M.C.**—Member of Council. C.M.—Corresponding Member.

V.P.	**Abney, Sir William** C.B., D.Sc., F.R.S.	Adviser to the Board of Education, Member of Advisory Council for Education to the War Office (1903), late President of Royal Astronomical Society, Physical Society, &c. Rathmore Lodge, South Bolton Gardens, London, S.W.
	Addicks, W. R.	President of the United Electric Light & Power Co., New York City, and Vice-President of the Consolidated Gas Co. of New York, 4, Irving Place, NEW YORK, U.S.A. (4).
	Aldrich, T. H.	Engineer, National X-Ray Reflector Co., 235, West Jackson Building, CHICAGO, U.S.A. (2).
	Allom, G.	Electrical Engineer, 15, George Street, Hanover Square, LONDON, W. (3).
	Allen, E. *Mem. Inst. Gas Engineers.*	Vice-President of the Institution of Gas Engineers. The Liverpool United Gas Light Co., Duke Street, LIVERPOOL (1).
	Ambrose, Ernest	Assistant Engineer, Metropolitan Electric Supply Co., 11, Knight's Park, Kingston-on-Thames (2).
	Anderson, A. A.	Inspector's Department, South Metropolitan Gas Co., 45, Chalsey Road, Brockley, S.E. (2).
	Annacker, J. P.	Tech. Manager, The Globe Electric Co., Ltd., 62, Cranwich Road, Stamford Hill, LONDON, N. (1).
	Anzbock, J.	Vice-Chairman of the Verein der Gas und Wasserfachmännern, Selberstr. 80, VIENNA XII. (1).
	Arnold, W. F.	The General Electric Co., Ltd., 71, Queen Victoria Street, London, E.C. (1).
	Asdell, J. H., *M.Sc.*	Lighting Engineer, 29, Mostyn Road, Handsworth, Staffs (1).
C.M.	Ashe, Prof. S. W.	Engineer and Professor, General Electric Co., Harrison, N.J.
	Aston, J. E.	Acetylene Lighting Engineer, 25, Denmark Street, London, W.C. (4).
	Bache, W. J.	Borough Electrical Engineer, Eythorne, All Saints' Road, CHELTENHAM. (4).
M.C.	BAILEY, F.	Chief Engineer, City of London Electric Lighting Co., Ltd., 64, Bankside, S.E. (4)
	Barber, J. W.	Consulting Electrical Engineer and Cinematograph Expert, Argyle Chambers, 106, Charing Cross Road, London, W.C. (1).
	Barfield, E. P., *A.M.I.E.E.*	Manager of Incandescent Lamp and Fittings Dept., Messrs. Siemens Bros., Ltd., Tyssen Street, Dalston, LONDON (1).

	Barham, G. B., *A.M.I.E.E.*	Electrical Engineer and Journalist, 347, Kingston Road, Wimbledon, LONDON, S.W. (1).
	Barham, G. R.	Works Manager, The British Luxfer Prism Syndicate, Daylight Experts, 16, Hill Street, Finsbury, LONDON, E.C. (1).
	Barkham, H. C.	Electrical Engineer, The Gables, Jaffray Road, Erdington, BIRMINGHAM (1).
	Barlow, H. D.	Electrical Contracting Engineer, Albion House, 61, New Oxford Street, London, W.C. (1).
C.M.	Bassett-Jones, W., JUN.	Lighting Engineer, 1, Madison Avenue, NEW YORK.
C.M.	Bast, Prof. O. de	Professor in the University of Liège; Member of Int. Electrotechnical Commission, 16, Rue César Franck, LIÈGE, Belgium.
	Baugh, J. H. Agar	92, Hatton Garden, LONDON, E.C. (1).
M.C.	BAYLISS, PROF. W. M., *M.A., D.Sc., F.R.S.*	Professor of General Physiology at University College, London, St. Cuthbert's, Hampstead Heath, LONDON (1).
	Beeton, H. R.	Chairman of the Brompton Electricity Co., 254, Earl's Court Road, S.W. (1).
V.P., C.M.	**Bell, Dr. Louis**	Consulting Electrical Engineer of the Edison Electric Illuminating Co., 120, Boylston Street, BOSTON, U.S.A.
	Berridge, T., *A.M.I.C.E.*	Engineer, The Gas Works, Leamington Prior (2).
C.M.	Bertelsmann, Dr. W.	Chemist to the Municipal Gas Works, Berlin, Waidmannslust, near Berlin.
C.M.	Besso, A.	Consulting Electrical Engineer, Via Angiolena 14, Gorizia, Austria.
	Beutell, A. W., *A.M.I.E.E.*	Electrical Engineer, 203, Victoria Street, S.W., and 2, Voss Court, Streatham Common South, LONDON, S.W. (1).
	Bevington, S. A.	Lighting Engineer to the Blackman Export Co., Ltd., The Haven, Grove Park Road, Grove Park, Lee, S.E. (4).
	Blackmore A.	Electrical Contractor, 5, Montpelier Street, LONDON (1).
	Blatchley, C. P. *B.A. Oxon, F.C.S.*	Managing Director of the County Light Co., Ltd., 13, Templars Avenue, Golders Green, London, N.W. (1).
C.M.	Blau, Dr. F.	Electrical Engineer, 4, Nagler Strasse, BERLIN.
C.M.	Bloch, Dr. L.	Lighting Engineer of the Berlin Electricity Supply Co., Member of the Photometrical Committee of the Verband Deutscher Elektrotechniker, Grolmanstr. 39, Charlottenburg, GERMANY.
	Blok, A. *B.Sc., A.M.I.E.E.*	Lecturer in Electrical Engineering, Croydon Polytechnic, 17, Epsom Road, Croydon, Surrey (2).
V.P., C.M.	**Blondel, Prof. A.**	Professor of Electrical Engineering, Chief Engineer of the Lighthouse Service of France, 41, Avenue de la Bourdonnais, PARIS.
C.M.	Blondin, Prof. J.	Professor of Physics at the Collège Rollin; Tech. Editor of *La Revue Electrique*; Member of Int. Electrotechnical Commission, 171, Faubourg Poissonnière, PARIS.
C.M.	Bocquet, J.	Chief Engineer, l'Association Normande pour prevenir les Accidents du Travail, 26, Rue Jeanne d'Arc, Rouen.
	Bohle, H.	Professor of Electrotechnics, South African College, CAPETOWN, S. Africa (1).
C.M.	Böhm, Dr. C. R.	12, Meinekestrasse, BERLIN, W. 15.
C.M.	Böhm, M.	Consulting Engineer to the Gasworks of Milan; Member of Int. Photometric Commission, 43, Via Vittoria, MILAN.
	Bond, C. F.	Inspector's Department, South Metropolitan Gas Co., 86, St. Mary's Road, Peckham, LONDON, S.E. (2).

	Bond, C. O.	Manager of the United Gas Improvement Co., Photometrical Laboratory, PHILADELPHIA, U.S.A. (2).
	Bond, H. I	Lighting Engineer to the London & South Western Railway, Engineer's Office, Waterloo Station, London, S.E. (2).
	Bond, J.	Engineer and Manager, Gas Works, SOUTHPORT (1).
	Bosenberg, A.	Fittings Manufacturer, 5/f. Serrestr., DRESDEN (1).
C.M.	Boucherot, Prof. P.	Consulting Engineer ; Member of Int. Electrotechnical Commission ; Professor at l'École de Physique et Chimie Industrielle de la Ville de Paris, 64, Boulevard Auguste Blanqui, PARIS.
	Brereton, Mrs. M. A. Cloudesley	Author, Editor of *The Gas Bulletin*, 7, Cannon Place, Hampstead (4).
	Broadberry, A. E.	Chief Engineer, Tottenham and Edmonton Gas Co., 639, High Road, Tottenham, London, N. (1).
C.M.	Broca, Dr. A.	Agrégé de la Faculté de Médecine, 7, cité Vaneau, PARIS.
V.P.	**Browne, Sir J. C.** *F.R.S.*	Vice-President and Treasurer of the Royal Institution, &c., Grindau, Dumfries, Scotland.
	Buckle, C.	Fire Insurance Official, "Sunset," Meopham, Kent. (2).
V.P., C.M.	**Budde, Dr. E.**	Professor of Electrical Engineering, President of the International Electrotechnical Commission, President of the Verband Deutscher Elektrotechniker, 54, Berlinerstr. CHARLOTTENBURG, Germany.
V.P., C.M.	**Bunte, Prof. H.**	Professor at the Technische Hochschule, KARLSRUHE, Gen. Secretary of the Verein von Gas- und Wasserfachmännern, Editor of the *Journal für Gasbeleuchtung.*
	Burgess, A. E. C., *M.I.E.E.*	Electrical Engineer, 13, Royal Exchange, Bridge Street, Sydney (4).
	Bush, W. E.	Lighting Dept., British Thomson-Houston Co., 77, Upper Thames Street, LONDON, E.C. (4).
	Butts, E. W.	Engineer to Holophane, Ltd., 26, Palewell Park, East Sheen, S.W. (1).
	Bytham, W. H.	Electrical Engineer, Canadian Union Electric Co., 9, St. Nicholas Street, Montreal (2).
C.M.	Calzavara, Capt. V.	Editor and Director of *Il Gaz*, VENICE, Italy.
	Campbell, G.	The Benjamin Electric, Ltd., 117, Victoria Street, LONDON, S.W. (1).
	Carlisle, T. H.	3, Orchard Studios, Brook Green, London, W. (1).
C.M.	Carozzi, Dr. L.	Doctor of Medicine at the Instituti Clinici di Perfezionamento, Corso San Celso, 6, MILAN.
C.M.	Castello, Señor A.	Engineer in the Department of Weights and Measures ; Member of Int. Electrotechnical Commission, Ministero de Fomento, MEXICO.
	Chalmers, S. D.	Head of the Dept. of Tech. Optics of the Northampton Institute, 25, Cornwall Road, Stroud Green, LONDON, N. (1).
	Chandler, S. B.	Distribution Dept., South Metropolitan Gas Co., 8A, Peak Hill Avenue, Kirkdale, Sydenham, LONDON, S.E. (4).
	Chapman, W. P.	Lighting Expert and Salesman to the Holophane Co., 16, East 40th Street, NEW YORK (4).
C.M.	Châtelain, Prof. de	President of the Russian Electrotechnical Committee ; Professor at the Institut Polytechnique, Sosnowka, ST. PETERSBURG.
	Chiswell, J. J.	Speldhurst, Queen's Road, Hendon, N.W. (2).
	Clark, H. N., *M.Inst. Gas Engineers*	Assistant Engineer to the West Ham Gas Co., Stratford, LONDON, E. (1).
	Clark, J. G.	Testing Assistant of the Gas Light and Coke Co., Horseferry Road, London, S.W. (1).
	Clevesley, A. J.	Engineer and Expert in Petrol Air-Gas Lighting, 58, Dunedin Road, LEYTON, Essex (1).

	Clinton, Prof. W. C.	Assistant Professor of Electrical Engineering, University College, London, 43, Stanhope Gardens, Highgate, LONDON (1).
C.M	Coblentz, Dr. W. W.	Physicist to the Bureau of Standards, WASHINGTON.
	Cook, S. O.	Engineer to Holophane, Ltd., 12, Carteret Street, Westminster, S.W. (1).
	Coote, E.	Manager, Lamp Sales Dept., British Thomson-Houston Co., 83, Cannon Street, LONDON, E. C. (4).
	Corin, W.	Chief Electrical Engineer, Public Works Department, SYDNEY, New South Wales (2).
	Cotton, H. F.	Superintendent of Public Lighting, Corporation of Dublin, 74, Mirrion Road, Ballsbridge, Dublin (4).
	Cowper Coles, S. V.	Electrometallurgist, &c., 1, Old Pye Street, LONDON, S.W. (1).
M.C.	COX, F. J., *M.I.M.E.*	Consulting Engineer to the Machine Gas, Ltd., 212, Brecknock Road, Tufnell Park, LONDON, N. (1).
V.P.	**Crookes, Sir Wm.** *F.R.S.*	Past President of the Inst. of Electrical Engineers, 7, Kensington Park Gardens, LONDON, W.
	Cross, W.	Electrical Contractor, Messrs. Falconer, Cross & Co., 7 and 9, Ridley Place, NEWCASTLE (2).
	Crow, H. W.	Tar Distiller, "Phasis," Blake Hall Crescent, Wanstead, ESSEX (4).
	Crowley, J. F., *B.A., M.Sc., A.M.I.E.E.*	Electrical Engineer, Messrs. Siemens Bros., Ltd., 196, Deansgate, Manchester (3).
	Crush, F.	46, The Avenue, Bedford Park, London, W. (1).
	Cunnington, A.	Assistant Lighting Engineer to L. & S. W. Rly., 26, Muncaster Road, Clapham Common, LONDON, S.W. (4).
	Cunnington, W.	13, The Chase, Clapham Common, LONDON, S.W. (1).
M.C.	DARCH, J., *F.S.I., M. Roy. San. Inst.*	Surveyor, 55, West Side, Wandsworth Common, LONDON, S.W. (1).
C.M.	David, Ch.	Chief Engineer in the Laboratoire Central d'Electricité; Secretary of the French Electrotechnical Committee, 14, Rue de Stael, PARIS.
	Davidson, T.	Glass Manufacturer, Team's Glassworks, Gateshead, Newcastle-on-Tyne (4).
	Davies, A. J. Devereux	H.M. Asst.-Inspector of Factories, Gresham Chambers, Kingsway, CARDIFF (2).
	Davis, S.	Publisher and Advertising Contractor, 1, Army and Navy Mansions, Victoria Street, London (1).
	Deane, R.	Inspector of Irish Lighthouses, Irish Lights Office, DUBLIN, Ireland (1).
	Deladrière, L.	Directeur de l'Association des Industriels de Belgique contre les accidents du travail, 38, Rue de l'Automne, Brussels (2).
C.M.	Deville, St. Claire	Chief Engineer of the Experimental Dept. of the Société du Gas, Paris, Member of the International Photometrical Commission, 73, Boulevard Berthier, PARIS.
	Dibdin, R.A.	Chemist and Gas Engineer, Edinburgh Mansions, Victoria Street, LONDON, S.W. (1).
	Dixon, H. L.	Chief Engineer, Leatherhead and District Electricity Co., Ltd., Bridge Street, Leatherhead (4).
	Doane, S. E.	Electrical Engineer of the National Electric Lamp Association, OHIO, U.S.A. (4).
	Dobson, S. T.	Chief Engineer, St. James and Pall Mall Electric Light Co., Joint Engineer, Central Electric Supply Co., 19, Carnaby Street, Golden Square, W. (1).
	Donnison, E. G.	Engineer, 14, Station Buildings, Claremont Road, Surbiton (1).
	Douglas, W. D.	Assistant in the Department of Physics and Electrical Engineering, Dublin Royal College of Science, 20, Garville Avenue, Rathgar, DUBLIN (1).
M.C.	Dow, J. S.	Asst. Editor of *The Illuminating Engineer*, Mayfield, Shepherd's Hill, Highgate, LONDON (*Secretary*) (1).

	Downe, R. S., *M.I.E.E.*	Electrical Engineer and Manager of the Brompton and Kensington Electricity Supply Co., Brompton Electricity Works, 254, Earl's Court Road, LONDON, S.W. (1).
V.P., C.M.	**Drehschmidt, Prof. H.**	Chief Chemist of the Municipal Gas Works, Tegel, BERLIN.
	Driver, F. P.	Works Manager, Osram Lamp Works, Hammersmith, 11, Amherst Avenue, Ealing, LONDON, W. (3).
	Drysdale, Dr. C. V. *M.I.E.E.*	White Sand, Grammar School Hill, REIGATE (1).
	Dumont, E. S.	Electrical Engineer, Benjamin Electric Co., Ltd., 31, Peter Street, LONDON, W. (1).
	Dyke, G. B.	Demonstrator in Electrical Engineering, University College, Thelma, Stanhope Road, Highgate, LONDON, N. (1).
	Eastman, R.	Lighting Expert to the British Thomson-Houston Co., National Buildings, Parsonage, Manchester (1)
M.C.	Eck, J. *M.I.E.E.*	Manager and Chief Engineer of the Union Electric Co., Park Street, Southwark, LONDON, S.E. (1).
	Edgcome, J. E. *M.I.M.E., M.I.E.E.*	Consulting and Borough Electrical Engineer, Electricity Station, Kingston-upon-Thames, Past President of the Incorporated Municipal Electric Association (1).
	Edgcumbe, K. *M.I.E.E.*	Electrical Engineer, Instrument Manufacturer, &c., Collindale Works, Hendon, LONDON, N.W. (1).
	Eisenmenger, H.	Nela Buildings, East Cleveland, Ohio, U.S.A. (2).
C.M.	Eitner, Dr. O.	Professor at the Tech. Hochschule, Karlsruhe; Member of Int. Photometric Commission, KARLSRUHE, Germany.
V.P., C.M.	**Elliott, E. L.**	One of the Founders of the Illuminating Engineering Society in the United States, 15, West 38th Street, NEW YORK, U.S.A.
V.P., C.M.	**Elliott, Dr. A. H.**	Chief Chemist and Director of the Consolidated Gas Co., Chairman of New York Section of the Illuminating Engineering Society (U.S.A.) in 1910, 165, Broadway, NEW YORK.
	Ellis, S. T.	Electrical Engineer, 54, Saltwell Road, Gateshead-on-Tyne (1).
	Elwell-Smith, H.	Electrical and Petrol Air Gas Engineer, Director and Manager of Spenser's, Ltd., 53, South Molton Road, LONDON, W. (1).
	Elworthy, H. S., F.R.C.S.	Surgeon, Inspector of injured workmen to the Ebbw Vale Steel Iron and Coal Co., Ltd., Treve Cottage, Ebbw Vale, R.S.O., Monmouthshire (2).
	Ernst, A. A.	Lighting Engineer, Holophane, Ltd., Carteret Street, S.W. (1).
	Ettles, Dr. W. J W., *M.D., F.R.C.S.E.*	Ophthalmic Surgeon, Pathologist to the Royal Eye Hospital, London, 114A, Harley Street, LONDON, W. (1).
	Evered, J. E.	Manager United Kingdom Lighting Trust, Ltd., 231, Strand, LONDON, W.C. (1).
	Fabling, H.	Inspector's Department of the South Met. Gas Co., 76, Manor Road, Brockley, LONDON, S.E. (2).
	Fairbrother, G. T.	Electrical Engineer, 25, Uxbridge Road, Shepherd's Bush, LONDON (1).
C.M.	Feldmann, Prof. C.	Electrical Engineer and Professor at the Tech. Hoogeschoole, DELFT, Holland.
	Ferguson, W., *M.I.C.E., M.I.M.E.*	Managing Director of the Wellington Gas. Co., 131, Cormandel Street, WELLINGTON, New Zealand (2).
	Findlay, J.	Managing Director of the Rugby Lamp Co., Ltd., 92, Lower Hillmorton Road, RUGBY (1).
	Fisher, W. Clark	24, Albany Road, EALING.
V.P.	**Fleming, Prof. J. A.** *D.Sc., F.R.S.*	Professor of Electrical Engineering at University College, Gower Street, LONDON.

	Fletcher, J. Y.	Electrical Engineer, 69, Queen Victoria Street, LONDON, E.C. (1).
	Flurscheim, A.	Representative of Messrs. Julius Pintsch of Berlin, 40, Woburn Square, LONDON, W.C. (1).
	Ford, W.	Divisional Inspector, Gas Light and Coke Co., 148, Goswell Road, London, E.C. (1).
	Foulds, M.	Manager, Westinghouse Cooper-Hewitt Co., 80, York Road, King's Cross (2).
	Francis, E. M.	Journalist, 13, Bream's Buildings, LONDON, E.C. (1).
	Freeth, T. C.	Electrical Engineer, 38, Bishops Mansions, Fulham Road, London, S.W. (1).
	Froget, A.	Engineer to Holophane, Ltd., 25, Avenue de la République, PARIS (3).
	Gans, Dr. F., *M.R.C.S.*, &c.	Ophthalmic Surgeon, Balfour House, Finsbury Pavement, LONDON, E.C. (1).
C.M.	Gariel, Prof. C. M.	Professor of Medicine; Chief Inspector of Railways and Bridges; President of the French State Committee on Illumination, 6, Rue Edouarde Detaille, PARIS.
V.P., C.M.	**Gartley, W. H.**	Chief Engineer of Philadelphia Gas Works, Past Vice-President of the American Gas Institute, Past President of the Illuminating Engineering Society (U.S.A.), 1401, Arch Street, PHILADELPHIA.
M.C.	GASTER, L.	Consulting Engineer and Editor of *The Illuminating Engineer*, &c., 32, Victoria Street, LONDON, S.W. (*Hon. Secretary*) (1).
	Gaster, Dr. A. *M.R.C.P.*	Physician, 68, Greencroft Gardens, Hampstead, LONDON, N.W. (1).
	Gibson, J.	Sales Manager to the British Westinghouse Electric and Manufacturing Co., Ltd., Long Millgate, Manchester (4).
	Girdleston, H.	Lighting Engineer to the British Thomson-Houston Co., Ltd., 41, Church Street, Sheffield (2).
	Glyn, Geoffrey Carr, *Major, D.S.O.*	Managing Director, Holophane, Limited, Howbury Hall, Bedford (1).
C.M.	Göhrum, F.	Director, Municipal Gas Works, STUTTGART, Germany.
	Gooch, F. H.	Electrical Engineer, 96, Elgin Avenue, Maida Vale, London (4).
M.C.	GOODENOUGH, F. W. *Mem. Inst. Gas Engrs.*	Sales Controller of the Gas Light and Coke Co., Horseferry Road, LONDON, S.W. (*Chairman of Council*) (1).
C.M.	Granjon, R.	Editor of the *Revue des Éclairages*, 104, Boulevard de Clichy, PARIS.
C.M.	Grau, Prof. A.	28, Wattmanngasse, VIENNA.
	Green, W.	St. James and Pall Mall Electric Light Co., 19, Carnaby Street, Golden Square, W. (1).
	Greenslade, C. E.	Instructor in Electrical Engineering, Crawford Technical Institute, Cork, IRELAND (2).
	Grigsby, B. J.	Managing Director of Benjamin Electric, Ltd., 1A, Rosebery Avenue, London, E.C. (3).
C.M.	Guiselin, A.	Engineer of the Compagnie Industrielle des Petroles, Secretary of the Commission Internationale du Petrole, 39, Rue Maubeuge, PARIS.
C.M.	Hahn, Prof. Dr. M.	Professor in the University of Munich, 30, Arcisstrasse, MUNICH.
C.M.	Halbertsma, N. A.	Electrical Engineer, Technical Adviser to Messrs. Tauber (Wiesbaden, Germany), Projection Arc Lamp Manufacturers, 20[1] Riedlingerstrasse, Darmstadt, Germany.
V.P.	**Haldane, Dr. J. S.** *F.R.S.*	Professor of Physiology at Oxford University, Gas Referee, &c.
	Hale, F. H.	Electrical Engineer, Warrenhurst, London Road, Bromley, Kent (1).
M.C.	HAMP, STANLEY, *A.R.I.B.A.*	36, Bloomsbury Square, LONDON, W.C. (1).

	Harrington, James	Electrical Engineer, President of the London Association of Foremen Engineers and Draughtsmen, 41, Berners Street, Oxford Street, LONDON, W. (1).
M.C.	HARRISON, HAYDN T. *M.I.E.E.*	Electrical Engineer, 11, Victoria Street, LONDON (1).
	Harrop, G.	Director of the Plaissetty Mantle Manufacturing Co., &c., Parkfield Works, Leyton, London, E. (2).
	Hart, J. H. E.	Late Chief Engineer, P.W. Dept., India, 9, Pendennis Road, STREATHAM, England (1).
M.C.	HASTINGS, C. W. *M. Inst. Gas Engrs.*	Editor of *The Gas Engineer's Magazine*, 5, Trinity Road, WIMBLEDON, England (1).
	Hawkins, F. J.	Lamp Dept., Brit. Thomson-Houston Co., RUGBY (4).
	Head, H. C.	Engineer and General Manager, Winchester Water & Gas Co., 19, Staple Garden, WINCHESTER (2).
	Helps, D. H.	Engineer, The Gas Works, King's Road, READING (2).
	Herbert, Lieut.-Col. D.	Old Bank House, Sherborne, Dorset (4).
	Herbert, G.	Lighting Engineer to the Benjamin Electric Co., 117, Victoria Street, LONDON, S.W. (1).
C.M.	Herzog, J.	Electrical Engineer, V. Leopoldring 18, BUDAPEST.
M.C.	HICKMAN, Dr. H. R. B., *M.A., M.B.(Oxon.), M.R.C.S., L.R.C.P.*	Ophthalmic Surgeon, 5, Harley Street, London, W., and White Hill House, Chesham, Bucks, England (1).
	Higgins, G.	East Rand Proprietary Mines, JOHANNESBURG (4).
	Hind, W. S.	Sales Dept. of Marylebone Municipal Electric Supply, Westholme, Rutland Road, Harrow, MIDDLESEX (4).
	Hoddle, C.	The Thorn and Hoddle Acetylene Co., Ltd., 151, Victoria Street, LONDON, S.W.
	Hollanda, R. de	6, Tavistock Square, LONDON (2).
	Holmes, H. H.	Sales Manager, Marylebone Municipal Electric Supply, 15, Lonsdale Road, Leytonstone, ESSEX (4).
	Holt, E. C.	Divisional Inspector, Gas Light and Coke Co., 2, Gainsborough Road, Leytonstone, Essex (1).
	Howgrave-Graham, R. P.	Demonstrator in Electrotechnics at Finsbury Technical College, 21, Worsley Road, West Hampstead, LONDON, N.W. (2).
	Howling, W. H.	Designer, 12, King's Road, Wimbledon, Surrey (1).
	Humphrey, G. W.	Electrical Engineer, 10, Victoria Avenue, Canton, Cardiff (1).
	Humphrys, N. H. *A.M.Inst.C.E. F.C.S. M. Inst. Gas Engrs.*	Manager of the Salisbury Gas Co., Consulting Engineer, SALISBURY (1).
	Hunt, H. F. *A.M.I.E.E.*	Electrical Engineer under the Admiralty at H.M. Dockyard, Pembroke Dock, WALES (1).
	Hunter, W. G.	116, Tollington Park, W. (4).
	Huntley, R.	Works Manager to Metalite, Ltd., 44, St. Giles Road, DERBY (1).
C.M	Hyde, Dr. E. P.	Director of the Laboratory of the National Electric Lamp Association, 4503, Hough Avenue, CLEVELAND, Ohio.
M.C.	IFE, J. WYATT	Lighting Engineer, 12, Carteret Street, LONDON, S.W. (*Hon. Treasurer*) (1).
C.M.	Ives, Dr. H. E.	Physicist in the Laboratory of the United Gas Improvement Co., 3101, Passyrunk Avenue, Philadelphia.
	Jackson, H.	Electrical Contracting Engineer, 19, Berners Street, London, W. (4).
	Jacoby, H. A.	Messrs. Krupka & Jacoby, 26-36, Chapter Street, Westminster, S.W. (2).
	Jenkinson, B. H. *A.M.I.E.E.*	Consulting Engineer, 9, Gray's Inn Square, LONDON, W.C. (1).

	Jenner, H.	Manager, Elec. Engineering Dept. of F. Sage & Co., Ltd., 68, Gladstone Avenue, Manor Park, LONDON, E. (2).
	Johnston, J. W.	Paper Manufacturer, St. Ann's, Hendon, London, N.W. (2).
	Jones, H. W.	Electrical Engineer, Chief Electrical Engineer of Waterloo and City Railway, 14, Cranes Drive, SURBITON, Surrey (1).
	Jones, J. H.	Designer, 29, Lorne Road, Stroud Green, Hornsey, London, N. (1).
	Jones, L. E.	38, Bedford Court Mansions, Bloomsbury (4).
	Kann, E. A.	The General Electric Co., Ltd., 67, Queen Victoria Street, London, E.C. (1).
	Kendrick, H. *M. Inst. Gas Engrs.*	Chief Engineer, Gas Company, STRETFORD (1).
	Kennard, E. G.	In charge of the Photometrical Laboratory, Engineer-in-Chief's Dept., G.P.O., LONDON, 91, High Road, Lee, LONDON, S.E. (1).
V.P.	**Kennelly, Prof. Dr. A. E.**	President of the American Illuminating Engineering Society, Professor of Electrical Engineering, Harvard University, CAMBRIDGE, Mass., U.S.A.
	Kerr, Dr. James	Medical Officer, London County Council Education Offices, Fitzalan House, Arundel Street, LONDON, W.C., and 15, Hanger Lane, Ealing, LONDON, W. (1).
	Kinzbrunner, Dr. C.	68, Hampstead Way, LONDON, N.W. (1).
	Kitson, A.	Managing Director of the Kitson Empire Lighting Co., Stamford, Lincolnshire (1).
	Knight, J. D. *A.M.Inst.C.E., M.Inst.M.E., M.I.E.E., &c.*	Borough Electrical Engineer, Ealing Town Hall, EALING, England (1).
	Körting, Max	Arc Lamp Manufacturer, LEIPZIG, Germany (2).
	Krupka, O.	Messrs. Krupka & Jacoby, 26-36, Chapter Street, Westminster, S.W. (2).
V.P., C.M.	**Krüss, Dr. H.**	Manufacturer of Optical and Photometrical Apparatus, Chairman of the Photometrical Committee of the Verein von Gas- und Wasserfächmannern, Adolpsbrucke, 6, HAMBURG, Germany.
	Lakin-Smith, C.	Engineer, County Engineering and Lighting Co., Ltd., &c., 10, Colonnade, New Street, Birmingham (1).
C.M.	Landry, Prof. J.	Professor of Electrical Engineering at the University of Lausanne, Secretary of the Swiss Electrotechnical Committee, 57, Avenue de Rumine, LAUSANNE.
	Langlands, S. B.	Chief Inspector, Glasgow Corporation Public Lighting Dept., 52, College Street, GLASGOW (2).
C.M.	Langlois, Prof. J. P.	Professeur Agrégé à la Faculté de Médecine, 155, Boulevard St. Germain, PARIS.
V.P., C.M.	**Lansingh, V. R.**	Late President of the Illuminating Engineering Society (U.S.A.), 29, West 39th Street, NEW YORK, U.S.A.
V.P., C.M.	**Laporte, F.**	Civil and Mining Engineer, Asst. Director of the Laboratoire, Central d'Electricité, 12 and 14, Rue de Stael, PARIS.
C.M.	Lauriol, P.	Chief Engineer of the Lighting Department of the City of Paris, 37, Avenue Élisée Reclus, PARIS.
M.C.	LEESE, COL. W. F.	Director of Brompton Electricity Co., The Costa Rica, and the Rosario Electric Cos., &c., 17, Carlton Road, Ealing, LONDON (1).
M.C.	LEIGH, F. A. CORTEZ	Chief Electrical Engineer, London and N. Western Railway, Euston Station, London, N.W. (2).
M.C.	LESSING, DR. R. *Ph.D., F.C.S.*	Consulting and Analytical Chemist, Southampton House, 317, High Holborn, LONDON (1).
M.C.	LEVY, DR. A. H. *M.D., F.R.C.S., &c.*	Ophthalmic Surgeon, Central London Ophthalmic Hospital, &c., 67, Wimpole St., LONDON, W. (2).

V.P.	**Lewes, Prof. Vivian**	Lecturer at the Royal Naval College, Greenwich, City Gas Examiner, &c., 30, Croom's Hill, Greenwich, LONDON, S.E.
	Liberty, W. J.	Public Lighting Inspector, City of London, 55, Beckwith Road, Herne Hill, LONDON, S.E. (4).
C.M.	Libesny, A.	Electrical Engineer and Physicist, Rotherstrasse 20–23, BERLIN O. 17.
C.M.	Liebenthal, Dr. E.	Technische, Physikalische Reichsanstalt, Charlottenburg, Berlin.
	Light, G. M.	Hon. Solicitor of the Illuminating Engineering Society (London), 1, Laurence Pountney Hill, Cannon Street, LONDON, E.C. (1).
	Lock, H. M.	Electrical Engineer, 55, Rutland Park Mansions, Willesden Green, LONDON, N.W. (3).
C.M	Lombardi, Prof. L.	Professor at the University of Naples; President of the Int. Electrical Congress at Turin, 1911; Member of the Int. Electrotechnical Commission, 173, S. Lucia, NAPLES.
	Lovinson, E.	Assistant Managing Director of the Welsbach Light Co., 24A, Sussex Square, Hyde Park, London, W. (1).
	Lüdecke, Dr. G.	Works Manager, Imperial Lamp Works, Brimsdown, Middlesex (2).
V.P., C.M.	**Lummer, Prof. O.**	University of BRESLAU, Germany.
	Lundberg, G. C.	Manufacturer of Electrical Accessories, Pioneer Electrical Works, 477–487, Liverpool Road, London, N. (2).
C.M.	Lux, Dr. H.	Editor of the *Zeitschrift für Beleuchtungswesen*, Director of the Beleuchtungs-Technische Laboratorium, 91 Bülowstr., BERLIN.
	Lynch, A. *M.P., L.R.C.P., &c.*	Civil Engineer, Member of the London Mathematical Society, &c., House of Commons, Westminster (2).
C.M.	Macbeth, N.	Lighting Expert to the Welsbach Co. of Gloucester, N.J., Weightman Building, PHILADELPHIA, U.S.A.
M.C.	MACFARLANE, O.P.	Manager of the Gas Economizing and Improved Light Syndicate, Ltd., 35, King's Avenue, Muswell Hill, London, N. (1).
	Macfarlane, M.	Incandescent Oil Lamp Manufacturer, care of Messrs. Yoshimoto & Co., 27, Sauchome, Sukayemachi, Kobe, JAPAN.
	Mackenzie, J. D.	Electrical Engineer, 217, West George Street, GLASGOW (1).
	Mackinney, V. H.	Optician and Lighting Engineer, 15, Coopers Lane, Grove Park, Lee, S.E. (1).
C.M.	MacMurtrie, F. C.	General Editor for the American Association for the Conservation of Vision, 1, Madison Avenue (Metropolitan Bridge), New York.
	Maistre, C. Le *M.I.E.E., A.M.I.C.E.*	Electrical Engineer, Gen. Sec. of the International Electrotechnical Commission, 28, Victoria Street, LONDON, S.W. (1).
	Manners-Smith, J. A.	Electrical Engineer, "Coniston," Haslemere, Surrey (1)
C.M.	Mantica, G.	Electrical Engineer, Director of the Italian Association of Users of Electrical Energy, Via Cernaja 11, MILAN, Italy.
	Marchant, Prof. E. W. *D.Sc., M.I.E.E.*	Professor of Electrical Engineering at Liverpool University, LIVERPOOL (1).
V.P., C.M.	**Marks, L. B.**	Consulting Engineer, Past President of the Illuminating Engineering Society (U.S.A.), 103, Park Avenue, NEW YORK, U.S.A.
	Marryat, H.	Electrical Engineer, Hon. Treasurer of Electrical Contractors' Association, 28, Hatton Garden, LONDON, E.C. (3).
C.M.	Marshall, A. J.	Manager, Architectural Dept. of Holophane Co., 16, East 40th Street, NEW YORK, U.S.A.

	Marshall, C.	Electrical Contractor, Managing Director of R. E. & C. Marshall, Ltd., Carlton Lawn, CHELTENHAM (1).
C.M.	Martens, Dr. F.	Professor and Director of the Physical Laboratory of the Handel Hochschule, Berlin, Spandauer Str. 1. BERLIN C. 2 (1).
C.M.	Massarelli, Ing. F.	Chief Inspector of the Associazioni degli Industriali d'Italia per prevenire gli Infortuni sul Lavoro avente Sede in Milano, 61, Foro Bonaparte, Milano.
	Mather, A. A.	Electrical Engineer, 36, Farringdon Street, E.C. (2).
	Mather, Prof. T. *F.R.S.*	Prof. of Electrical Engineering at the Central Technical College, Exhibition Road, South Kensington, LONDON, S.W. (4).
	Mathiesen, W.	Arc Lamp Manufacturer, LEIPZIG, Germany (2).
	Matthews, R. Borlase, *Wh.Ex., M.I.E.E., A.M.I.C.E.*	Electrical Engineer, 5, Gloucester Place, Swansea (1).
	Matthews, R. L.	Manager of the Linolite Co., 25, Victoria Street, London, S.W. (2).
	Maurice, G.	The General Electric Co., Ltd., 67, Queen Victoria Street, E.C. (4).
	Mayes, F.	Hope Villa, Linton Road, Barking, Essex (1).
	Mead, F. W.	Engineer of Public Works, BATHURST, Box 33, Gambia River, Africa (1).
	Merrett, J. A.	Consulting Engineer, 65, Nevsky Prospect, St. Petersburg, RUSSIA (2).
C.M.	Millar, P. S.	Gen. Sec. of the Illuminating Engineering Society (New York), 80th Street and East End Ave., NEW YORK, U.S.A.
Hon. Member.	**Moeller, Dr. A.**	President of the Académie Royale de Médecine, Member of the Commission des Accidents du Travail, President of the Congrès International des Maladies Professionnelles, Brussels, 1910, 1, Rue Montoyer, BRUSSELS.
C.M.	Monasch, Dr. B.	Member of the Photometrical Commission of the Verband Deutscher Elektrotechniker, 1903, German Chartered Patent Agent and Consulting Engineer, 3, Lampestrasse, LEIPZIG.
	Mond, Dr. E. S. *F.C.S.*	Chemical Manufacturer, 22, Hyde Park Square, LONDON, W. (1).
V.P.	**Mordey, W. M.** *M.I.E.E.*	Past President of the Institution of Electrical Engineers, 82, Victoria Street, LONDON, S.W.
	Morgan, H. E.	Inspector, South Metropolitan Gas Co., 12, Camden Avenue, Peckham, LONDON, S.E. (2).
	Morrell, R.A., *M.R.C.S., L.R.C.P.*	Ophthalmic Surgeon, 13, Harley Street, W. (3).
	Morris, Prof. J. T. *M.I.E.E.*	Professor of Electrical Engineering at the East London College, 36, Cumberland Mansions, Seymour Place, LONDON, W. (1).
	Moss, H.	Electrical Contractor, 116, Horton Grange Road, BRADFORD (1).
	Mostyn, R. J. F. *A.M.I.E.E.*	Electrical Engineer, Sandown, St. Minver Road, BEDFORD (2).
C.M.	Motais, Dr.	Physician and Secretary of the Comité Technique de l'Éclairage Naturel et Artificiel, 8, Rue St. Laud, Angus.
	Mygatt, O. A.	Director of Holophane Ltd., 12, Carteret Street, Westminster, LONDON (1).
	Nash, E. A. *A.I.E.E.*	The Electrical Standardizing, Testing, and Training Institution, Faraday House, 66, Southampton Row, LONDON, W.C. (1).
	Nicholls, M. E.	Chief Indoor Inspector of the South Met. Gas Co., 709, Old Kent Road, LONDON, S.E. (2).
	Norden, J.	Manufacturer of Incandescent Mantles, Fittings, &c., 44, Farringdon Street, LONDON, E.C. (1).

C.M.	Nuel, Dr. J. P.	Professor at the University of Liège, 28, Rue Louvreux, Liège.
C.M.	Oker-Blom, Dr. W.	University of Helsingfors, FINLAND.
C.M.	Ott, Dr. E.	Chemist to the Zurich Gas Works; Member of Int. Photometric Commission, Schlieren, ZÜRICH, Switzerland.
C.M.	Owen, H. Thurston.	Engineer and Lighting Expert, 13–21, Park Row, NEW YORK, U.S.A.
C.M.	Oya, A.	Member of Int. Electrotechnical Commission; Elec. Engineer, of the Imperial Electrotechnical Laboratory, Ministry of Communications, TOKYO, Japan.
	Palowkar, R. M.	Electrical Engineer, 67, St. Paul's Road, Highbury, LONDON, N. (1).
V.P.	**Parsons, Dr. J. H.** *F.R.C.S., &c.*	Ophthalmic Surgeon, Lecturer at University College, &c. 54, Queen Anne St., Cavendish Square, LONDON, W.
	Paterson, C. C. *M.I.E.E. A.M.I.C.E.*	In Charge of Electrotechnical and Photometrical Dept. of the National Physical Laboratory, Bushy House, TEDDINGTON, England (1).
M.C.	PEARCE, S. L. *M.I.C.E., M.I.E.E.*	Chief Electrical Engineer to the Manchester Corporation, Dickinson Street, MANCHESTER (Past Pres. of the Incorporated Municipal Electrical Assocn.). (1)
	Peronne, P. E.	Superintendent, Photometer Department, 12, Moore Park Road, Fulham, LONDON, S.W. (4).
	Peschke, Max	Manager, Holophane, G.m.b.H., 35, Dorotheenzstrasse, BERLIN N.W.7 (2).
C.M.	Picou, R. V.	Civil Engineer; President of the French Electrotechnical Committee, 41, Rue Saint Ferdinand, PARIS.
	Plumtree, J. S. *A.M.I.E.E.*	Electrical Engineer to the Union Electric Co., Park Street, Southwark (1).
Hon. Member.	**Pontiggia, Luigi.**	Directeur de l' Associazione degli Industriali d' Italia per prevenire gli infortuni del lavoro, Piazza Cavour 4, Milan.
	Porter, G.	Yarra, Feltham Avenue, East Molesley; Assistant Engineer to Edmundson's Electricity Corporation, Broad Sanctuary Chambers, WESTMINSTER, S.W. (1).
	Prangnell, N. W. *A.M.I.E.E.*	Electrical Engineer, Metropolitan Electric Supply Co., 16, Stratford Place, LONDON, W. (1)
Hon. Member, V.P.	**Preece, Sir Wm.** *K.C.B., F.R.S., &c.*	Consulting Electrical Engineer, Past President of the Institutions of Electrical and Civil Engineers, Penrhos, Carnarvon, NORTH WALES.
M.C.	RAWLINGS, W. R.	Electrical Contracting Engineer, Past President of the Electrical Contractors' Association, 82, Gloucester Road, South Kensington, S.W. (1).
	Rayment, A. J.	2, White Hart Street, Paternoster Square, E.C. (2)
	Recklinghausen, Dr. M. von.	Managing Director, Westinghouse Cooper Hewitt Co., 73, Boulevard Haussmann, PARIS (4).
	Redgment, G.	Electrical Engineer, 5, Bank Plain, Norwich (1).
V.P.	**Redwood, Sir B.** *D.Sc., F.R.S.E., F.I.C.*	Consulting Chemist and Adviser on Petroleum to the Home Office, 4, Bishopsgate Street Within, LONDON, E.C.
	Reilly, E. P.	Civil Engineer, Chief Engineer and Manager of the Cape Town and District Gas Company (4).
	Reiner, J. B.	Optician, 9. Vere St., Cavendish Square, LONDON (2).
	Reiter, Dr. C.	Chief Chemist of the Imperial Lamp Works, 17, Osborne Road, Brimsdown, MIDDLESEX (4).
	Richardson, A. H.	Engineer, Tottenham and Edmonton Gas Co., 51, Queen's Avenue, Winchmore Hill, London, N. (1)
	Rissel, A. K. W.	Electrician, late of Public Works Dept. of New Zealand, Canada Ford Company, 485, St. James's Street, MONTREAL, CANADA (1).
	Ritchie, T. E. *A.M.I.E.E., A.M.I.M.E.*	Chief Departmental Engineer, Lamp Dept., Union Electric Co., 20, Kingston Lane, TEDDINGTON (2).

	Robertson, C. E.	6, Park Lane, Clissold Park, London, N. (1).
C.M.	Rosemberg, R.	Editor of the *Revue des Eclairages*, 104, Boulevard de Clichy, PARIS.
	Ross, P.	Electrical Engineer, 17, Gresham Street, Liverpool (1).
C.M.	Rossander, C. A.	Electrical Engineer; Member of the Int. Electrotechnical Commission, Elektriska Pröfninganstalten, 38, Regeringsgatan, STOCKHOLM.
	Rowe, E. B.	Illuminating Engineering Dept. of the Holophane Co., NEWARK, OHIO, U.S.A. (1).
C.M.	Rumi, Prof. S. A.	Professor of General and Technical Physics at the R. Instituto Tecnico e Nautico of Genoa, Via S. Luca 3B, GENOA.
	Rylands, H. S.	Optician, 9, Vere Street, London, W. (4)
	Ryves, R. A. *A.M.I.C.E., &c.*	Consulting Engineer, "Mylapore," Stanley Road, West Croydon, England (1).
	Sainsbury, S. R.	Engineer to Brit. Westinghouse Co., Ward Buildings, High Bridge, NEWCASTLE-ON-TYNE (3)
C.M.	Sand, Dr. R.	Agrégé Chef des travaux anatomo-pathologiques à l'Université, 45, Rue des Minimes, BRUSSELS.
C.M.	Satori, K.	Engineer of the Electricity Supply Works, Theobaldstrasse 6, VIENNA.
C.M.	Schanz, Dr. F.	Ophthalmic Surgeon, 10 Münchenerplatz. DRESDEN.
	Scharrer, E.	Messrs. C. M. Brickman & Co., 41. Rutland Park Mansions, Willesden Green, LONDON, N.W. (1)
	Schiller, F.	III Hintere Zellamtstr., VIENNA, Austria (2).
	Scholtz, Max	Director of Messrs. Ehrich & Graetz, S.O. 36, Elsen Strasse 92/94, BERLIN (1).
C.M.	Schumann, Dr.	Chief Chemist to the Münich Gas Works, Thalkirchnerstrasse Gaswerke, MÜNICH.
	Schwabacher, Dr.	Engineering Chemist to the Machine Petrol Air Gas Syndicate, Ltd., Connaught Club, Marble Arch, LONDON, W. (1).
M.C.	SCOTT-SNELL, E.	Director of County Light, Ltd., Guildford Street, LONDON, S.E. (3).
C.M.	Seidener, J.	Secretary of the Institute of Electrical Engineers in Austria Hungary and Editor of *Elektrotechnik und Maschinenbau*, VIENNA.
V.P., C.M	**Sharp, Dr. C. H.**	Past President of the Illuminating Engineering Society (N.Y.), Chief of the Electrical Testing Laboratories, 80th St., and East End Avenue, NEW YORK, U.S A.
	Shaw, F.	Advertising Manager to the British Thomson-Houston Co., 21, Merlin Road, Manor Park, Essex (1).
	Slaughter, T. E.	Electrical Distribution Engineer, London Electric Supply Corporation, 25A, Cockspur Street, LONDON, S.W. (1).
M.C.	SMITH, H. S.	Manager, Acetylene Publicity, Ltd., 16, Beverley Gardens, Barnes, LONDON, S.W. (1).
	Solomon, M. *A.M.I.E.E.*	Manager of the General Electric Company's Carbon Works, Witton, Birmingham, Bradley, Grange Lane, Erdington, BIRMINGHAM (1).
C.M.	Steiner, V.	Editor of the *Zeitschrift für Gewerbe Hygiene*, 18, Am Tabor, 11/1, VIENNA.
C.M.	Steinmetz, Dr. C. P.	Chief Engineer of the General Electrical Co., Schenectady, N.Y., U.S.A.
	Stephens, J. N.	Electrical Engineer, Lamp Dept., British Thomson Houston Co., 40, Prince's Square, Hyde Park, LONDON, W. (4).
	Stevens, J. D. *A.M.I.E.E.*	Electrical Engineer, P.O. Box 1,782, JOHANNESBURG, S. Africa (1).
	Stevenson, J.	Secretary to the British Graetzin Light, Ltd. (Westminster), 51, Haslemere Road, Thornton Heath (1).
	Stewart, H. J. F. *A.M.I.E.E.*	Resident Engineer and Manager of the Ilfracombe Electric Light Co., Ltd., Hospital Road, ILFRACOMBE, England (1).

	Stickney, G. H.	Lighting Engineer to the General Electric Co., 5, Claremont Place, Montclair, N.J., U.S.A. (4)
C.M.	Stockhausen, Dr. K.	Electrical Engineer, Niedersedlitzerstrasse 5, Gross-Zschachwitz, DRESDEN.
	Stoeck, M.	The C.E.A.G. Electrical Safety Lamp Co. and the General Moore Electric Co., 19, St. Dunstan's Hill, London, E.C. (4).
M.C.	STOKES, A.	Chief Outdoor Inspector of the South Met. Gas Co., 709, Old Kent Road, LONDON, S.E. (2).
V.P.	**Stokes, L. A.** *F.R.I.B.A.*	President of the Royal Institute of British Architects, 2, Great Smith Street, LONDON, S.W.
C.M.	Strache, Prof. H.	Gas Engineer, Professor at the K.K.Tech. Hochschule in Vienna, Alserstrasse 71, VIENNA VIII.
C.M.	Strecker, Geh. Ober Postrat Prof. D. K.	President of the Commission of Symbols appointed by the Elektrotechnischer Verein, 106, Königgrätzerstrasse, BERLIN.
	Sunderland, L.	Electrical Contracting Engineer, 47, Victoria Street, London, S.W. (1).
C.M.	Süssenguth, Dr. A.	Chief of the Chemical and Lighting Section of the German Museum in Munich, Herzog Rudolfstrasse 29/II., MUNICH.
	Sutton, E. A.	129, Grosvenor Road, Highbury, London, N. (1).
Hon. Member.	SWAN, SIR JOSEPH. *M.A., F.R.S., D.Sc., &c.*	Past President of the Institution of Electrical Engineers, &c., Overhill, Warlingham, Surrey.
	Talbot. H.	Chief Outdoor Lighting Inspector to the South Metropolitan Gas Co., Old Kent Rd., LONDON, S.E. (2).
	Tamson, A. W. K.	Managing Director to the Batavo Co., Ltd., 3, Nieuwe-Schoolstraat, The Hague, HOLLAND (4).
	Taylor, A. L. *M.I.E.E.*	Chief Electrical Engineer to the Liverpool and London and Globe Insurance Co., Ltd., The Tithebarn, Great Crosby, LIVERPOOL (2).
	Taylor, F. H. *A.M.I.E.E.*	Consulting Engineer, 19, Old Queen Street, Westminster, LONDON, S.W. (1).
	Taylor, H. J.	Electrical Engineer, 63, Queen Victoria Street, LONDON, E.C. (1).
V.P., C.M.	**Teichmüller, Prof. J.**	Consulting Electrical Engineer and Professor of Electrical Engineering, Member of the Photometrical Commission of the Verband Deutscher Elektrotechniker (1909), Nowackanlage 2, KARLSRUHE, Germany.
C.M.	Terneden, Dr. L. J.	Member of Int. Photometric Commission; Engineer to the Corporation Gas Works, AMSTERDAM.
	Thomas, H. B.	Inspectors' Dept. South Met. Gas Co., 16, Bramble-down Road, WALLINGTON, Surrey (2).
Hon. Member. President	**Thompson, Prof. Silvanus P.** *D.Sc., F.R.S.*	Past President of the Inst. of Electrical Engineers, Professor of Electrical Engineering and Principal of the City and Guilds of London Technical College, Finsbury, E.C., "Morland," Chislett Road, West Hampstead, LONDON, N.W.
	Thomson, Alex., Jr.	Electrical Engineer to the Union Electric Co., 8, Hamilton Park Terrace, Hillhead, GLASGOW (2).
V.P.	**Thomson, Prof. Elihu**	Past-President of the Int. Electrotechnical Commission; President of the General Electric Co., WEST LYNN, Mass., U.S.A.
	Thomson, T. G.	57, Haselrigge Road, Clapham, LONDON, S.W. (1).
M.C.	THORNTON, S. E. *A.M.I.C.E.*	Chairman of Messrs. W. Sugg & Co., Sanctuary House, Tothill Street, LONDON, S.W. (2).
	Thorp, F.	Gas Engineer, Managing Director of Franklin Thorp & Co., Grasmere, Whitefield, near MANCHESTER (1).
	Thurley, C. A.	Gas Engineer, S. Metropolitan Gas Co., 21, Elynde Street, Crofton Park, LONDON, S.E. (1).
C.M.	Tolman, W. H.	Director of the American Museum of Safety, 29, West 39 Street, NEW YORK.
	Tomlinson, J. H.	Ophthalmic Surgeon, Tudor Lodge, Egham (1).

	Topley, W. H.	On the Staff of the Croydon Gas Co., 4, Walerand Road, Blackheath, LONDON, S.E. (1).
	Topley, W. W. *Mem. Inst. Gas Engrs.*	Secretary of the Croydon Gas Co., Katherine Street, CROYDON, England (1).
	Trewby, L. *Mem. Inst. Gas Engrs.*	Gas Engineer, Gas Works, MILL HILL, LONDON, N.W. (1).
	Trippe, C. F.	Electrical Engineer, Avalon, Pyrford, Surrey (1).
V.P., M.C.	**A. P. Trotter,** *M.I.E.E.*	Electrical Adviser to the Board of Trade, 8, Richmond Terrace, Whitehall, LONDON, S.W. (1).
	Tucker, A. G. *A.M.I.E.E.*	Electrical Engineer, 71, Grant Street, GLASGOW, W. (1).
V.P., C.M.	**Ubbelohde, Prof.**	Gen. Secretary of the International Petroleum Commission, KARLSRUHE, Germany.
V.P., C.M.	**Ulbricht, Prof.**	President of the Königl. Generaldirektion der Sächsischen Staatsbahnen, Member of the Photometrical Commission of the Verband Deutscher Elektrotechniker, Hettner Str. 3, DRESDEN.
	Van Goetham, J.	Welsbach Incandescent Gas Light Co., Gray's Inn Road, London, E.C. (1).
	Venner, R. F.	Electrical Engineer, 6, Old Queen Street, Westminster, LONDON, S.W. (1).
Hon. Member.	VERNON HARCOURT, PROF. A. G. *M.A., F.R.S.*	Past President of the Chemical Society, Metropolitan Gas Referee, &c., St. Clare, RYDE, Isle of Wight.
C.M.	Verstraeten, Th.	Member of Int. Photometric Commission; President of the Compagnie Generale du Gaz, 34, Rue Marie de Burgoyne, BRUSSELS.
V.P. C.M.	**Violle, Prof. J.**	89, Boulevard St. Michel, PARIS.
C.M.	Voege, Dr. W.	Asst. in the Physikalische Staatslaboratorium Hamburg, Member of the Photometrical Commission of the Verband Deutscher Elektrotechniker (1909), Tierischstrasse 170,1, HAMBURG, Germany.
M.C.	WALDRAM, P. J. *F.S.I.*	Surveyor, Civil Engineer, 12, Buckingham Street, Charing Cross, LONDON, W.C. (1).
	Walker, F. J.	Managing Director, St. James's and Pall Mall Electric Supply Co., 19, Carnaby Street, Golden Square, LONDON, W. (1)
	Walker, H.	Surveyor to the Law Union and Rock Insurance Co., 1, Old Serjeant's Inn, LONDON, E.C. (1).
	Walker, R. E.	Elec. Engineer and Contractor, Widemarsh Street, HEREFORD (2).
C.M.	Wallis, F. E.	Architect, 346, Fourth Avenue, NEW YORK.
M.C.	WALLIS-JONES, R. J. *M.I.C.E., M.I.E.E.*	Consulting Electrical Engineer, 50, Queen Anne's Gate, Westminster, LONDON, S.W. (1).
	Walmesley, Prof. R. M. *D.Sc., F.R.S.E.*	Principal of the Northampton Institute, 28, St. John Street, LONDON, E.C. (1).
	Walsh, B. P. K.	123, Queen's Road, Finsbury Park, N. (4).
	Walters, E. H.	Engineer-in-Chief's Office, G.P.O., LONDON, E.C. (4).
	Watson, J. F. *M.I.C.E., M.I.M.E.*	Consulting Engineer, Sun Buildings, Park Road, LEEDS (1).
	Wearing, A. B.	Electrical Engineer, Managing Director of the Canadian Union Electric Co., Ltd., 9, St. Nicholas Street, MONTREAL (2).
	Webber, W. H. Y.	Gas Engineer, Staff Instructor to the Gas Light and Coke Co., Isca, Udney Park, Teddington (1).
V.P., C.M.	**Weber, Prof. L.** *Ph.D.*	Professor of Physics at the University of Kiel, Moltkerstr. 60, KIEL, Germany.
V.P.	**Wedding, Prof. Dr. W.**	Professor at the Technische Hochschule, Charlottenburg, Gross Lichterfelde, Wilhelmstrasse, 2, BERLIN.
	Weekes, R. W. *M.I.E.E.*	Consulting Engineer, Maxwell House, Arundel Street, Strand, LONDON, W.C. (2).

C.M.	Weinbeer, E. W.	Electrical Engineer and Professor of Electrotechnics at Charlottenburg, 4 Röntgenstr., CHARLOTTENBURG, Germany.
	Weston, G. C. *A.M.I.E.E.*	Distribution Engineer to Kensington and Knightsbridge Electric Lighting Co., Prince Consort Road, South Kensington, LONDON, W. (1).
	Wheat, H. C.	Lighting Engineer to the British Thomson-Houston Co., B.T.H. London Lamp Works, Willesden (1).
C.M.	Whitney, Dr. W. R.	Director of Research Laboratory, General Electric Co., Schenectady, N.Y., U.S.A.
	Wild, L. *M.I.E.E.*	Director of the Westminster Electrical Testing Laboratory, York Mansions, York St., LONDON, S.W. (1).
	Willcox, F. W.	The British Thomson-Houston Co., Mazda House, 77, Upper Thames Street, LONDON, E.C. (4).
	Williams, J.	General Manager of the Foreign and Colonial Lighting Co., Ltd., Emberton Lodge, NEWPORT PAGNELL, England (1).
	Williams, W. H. *A.M.I.E.E.*	Manager of Lamp Dept. of the Electrical Co., 115, Lower Richmond Road, East Sheen, London, S.W. (1).
	Wilson, C.	Electrical Engineer, 80, Castlenau, Barnes, London, S.W. (1).
	Wilson, D. R.	H.M. Inspector of Factories, Home Office, Whitehall, LONDON, S.W. (4).
	Wingate, M. F.	Optician, 35A, Welbeck Street, London, W. (1).
	Wisé, W. C.	P. E. Chappins & Co., 85, Fleet Street, LONDON, E.C (1).
	Wohlauer, A. A.	Consulting Electrical Engineer and Lighting and Heating Expert, 546, Fifth Avenue, NEW YORK, U.S.A. (1).
V.P.	**Wood, Sir Henry Trueman.**	Secretary of the Royal Society of Arts, John Street, Adelphi, LONDON.
C.M.	Wrightington, E. N.	Vice-President of the Boston Consolidated Gas Co., 24, West Street, BOSTON, Mass, U.S.A.
	Yates, H. J. *F.C.S., M.I.M.E.*	Chairman and Managing Director of John Wright and Eagle Range, Ltd., Essex Works, Aston, Birmingham (4).
	Young, H. T.	Electrical Contractor, Messrs. Troughton & Young, 6, Park Mansions Arcade, Knightsbridge, London, S.W.

New Members of the Society.

THE names of applicants for membership read out at the previous meeting on April 29th* were formally announced at the Annual Meeting, on June 3rd, and these gentlemen declared members of the Illuminating Engineering Society.

In addition, the names of the following gentlemen have been duly submitted and approved by the Council, and were also read out by the Hon. Secretary at the Annual Meeting :—

Layton, W. T.	Editor of the South Met. Gas Co.'s *Journal*, 313, Friern Road, Dulwich, London, S E.
Hanson, R. J. E.	Surgeon Oculist, Hon. Surgeon-Oculist to Royal Albert Orphanage, &c., 5, Harley Street, London, W.
Perkins, H.	Messrs. Gibson, Battle & Co., Sydney.

Since the above date the name of Mr. T. Pye, of the Chichester Gas Co., has been duly placed before the Council.

---

* *Illum. Eng.*, Lond., June 1913, p. 306.

The Illuminating Engineering Society.

(Founded in London, 1909.)

ANNUAL SUBSCRIPTION, ONE GUINEA.

All Communications should be addressed to:—
L. GASTER, Hon. Sec.,
32, Victoria Street, London, S.W.

Application for Membership.

The members of this Society shall be designated Members, Honorary Members, and Corresponding Members.

A Member may be any one interested in the objects of the Society, but at the date of election shall not be less than twenty-one years of age.

Ordinary, Honorary, and Corresponding Members may be of either sex and of any nationality.

An application for admission to the Society shall be made in a form prescribed by the Council, and shall refer to at least two Members of the Society; or if an applicant certifies that he is not personally known to two members, references may be accepted to Members of professional societies of good standing, or to other persons whose good standing may be readily verified by the Council. If, in the opinion of the Council, further support for a Member's candidature be considered necessary, the recommendations of four existing Members shall be deemed sufficient; but the final consideration of a nomination for membership rests with the Council. (*Extract from Constitution*, see *Illuminating Engineer*, Lond., June, 1909, p. 377–382).

We hereby recommend:—

Name .....

Address .....

.....

Occupation, &c. .....

.....

.....

.....

.....

Date and Place of Birth .....

Here state name in full, date and place of birth, rank, profession or business, usual place of residence and qualifications for membership of the candidate.

as a fit and proper person to become a member of the Illuminating Engineering Society.

.....

.....

.....

*Here must follow the names of two or more nominators, one of whom must have personal knowledge of the candidate.

Date .....

Nomination approved by Council .....

Date of Announcement of Nomination .....

Date of Election .....

This portion to be filled up by Council.

The Illuminating Engineering Society.

(Founded in London, 1909.)

Abstracts from Constitution and Bye-Laws.

NATURE AND AIMS OF THE ILLUMINATING ENGINEERING SOCIETY.

The name of this Association shall be the Illuminating Engineering Society.

Its objects shall be the advancement of the theory and practice of illuminating engineering and the dissemination of knowledge relating thereto. Among the means to this end shall be meetings for the presentation and discussion of appropriate papers; the publication as may seem expedient of such papers, of discussions and communications; and through committees, the study of subjects relating to the science and art of illumination, and the publication of reports thereon.

Also the organization of, or participation in periodical national and international exhibitions of developments in illumination, and congresses dealing with the subject.

PUBLICATION OF PROCEEDINGS, &c., OF SOCIETY.

The Illuminating Engineer, published by the Illuminating Engineering Publishing Co., Ltd., in London, shall be the recognized official organ of the Society.

CO-OPERATION WITH OTHER INSTITUTIONS, &c.

The Council shall be at liberty to approach or to entertain and, if desirable, accept overtures from other Societies and Institutions with a view to joint discussions of subjects of mutual interest, exchange of transactions, and co-operation to secure Governmental action, for the advancement of the objects of the Society.

FEES AND SUBSCRIPTIONS.

The annual subscription (one guinea) is payable in advance. Applications for subscriptions shall be sent out quarterly by the Hon. Secretary.

I, the undersigned, desire to become a Member of the Illuminating Engineering Society, and hereby promise that, if elected, I will submit and conform in all respects to, and be governed by, the terms and provisions of the Constitution and the Bye-Laws made in pursuance thereof; provided that whenever I shall signify in writing to the Hon. Secretary that I am desirous of ceasing to be a Member thereof, I shall be free from this obligation, after payment of any Annual Subscription or arrears which may be due from me at that period.

Signature of Candidate.. ....

Date.....

Notes on Show-Window Lighting.

Mr. J. G. Henninger's article on 'Show-Window Lighting' and the ensuing discussion, which appeared in the May number of the *Transactions* of the U.S.A. Illuminating Engineering Society, are interesting as confirming many of the points raised in one of our articles on this subject.* He aptly likens the show-window to a stage. In both cases the main object is to obtain the most attractive and pleasing effect.

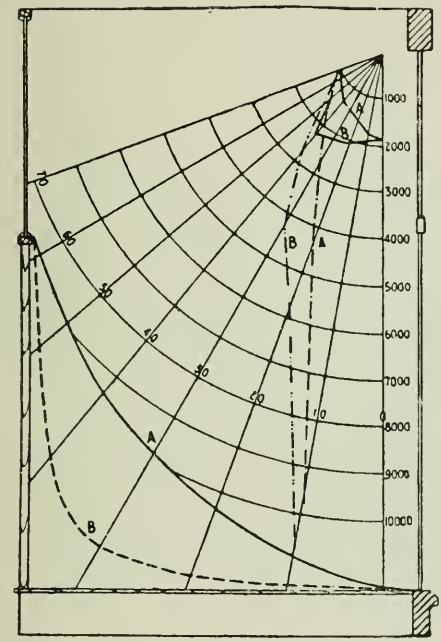
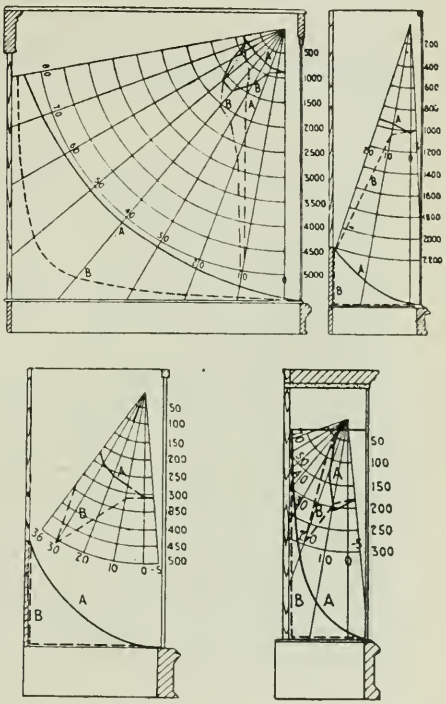


Fig. 1.—Planes of illumination in a very large window.

He takes the now-established view that the well-lighted window serves two purposes: (1) to arrest the attention of the passer-by, and (2) to cause the articles on display to stand out distinctly and to be seen at their best advantage. The eye should be undisturbed by the source of light: the units must, therefore, be completely screened from view.

The intensity of illumination necessarily varies with different localities, and in a main street, amongst large shops using brilliant lighting, the standard of illumination, must often be exceedingly high. Window illumination may vary from 5 to 25 foot-candles. In some cases windows have even been spoilt by the adoption of very brilliant street illumination, and merchants have sometimes in consequence been obliged



Figs. 2, 3, 4 and 5.—Planes of illumination in four windows of different sizes and styles.

to double or even treble the light in their windows. On the other hand, there have been instances in which shop owners have omitted to light their windows altogether, relying entirely upon the street illumination. Such externally lighted windows, however, have a dead appearance. The average illumination for large towns is above 15 foot-candles; the street illumination, therefore, would have to be excessive for there to be no contrast between it and a well-lit shop-window.

* Illum. Eng., Nov., 1912, p. 504.

The glare from some of the present high candle-power units in street lighting is objectionable, and should be discouraged.

In window lighting the background has to be taken into account: a dark background requires more light than a light one. It is impossible to get a background suitable for all exhibits, and it is a good plan to change both this and the illumination to suit the different merchandise shown. An economical method is the "Alternate System," which consists of one-half of the lights being on a separate circuit; for dark goods the full light would be used, whereas for light articles only half the lamps would be employed. A dark green ground is excellent for light or neutral coloured goods. For dark articles a light or neutral coloured ground is suitable. Contrast between object and ground is important. Very sharp contrasts, however, are not always desirable: taste and judgment must here be exercised. Clear-glass backgrounds are rarely satisfactory, on account of the reflection and the flimsy appearance of the window. Again, mirrors are not desirable; they certainly have the advantage of giving depth to a window, but the reflection of the passing traffic distracts the eye. Ripple glass or art glass is more satisfactory, as there is practically no surface reflection. Panelled woodwork surmounted with this kind of glass to admit light in daytime, is often used. The reflected images of the light may be corrected by hanging a shade in front of the glass at night-time.

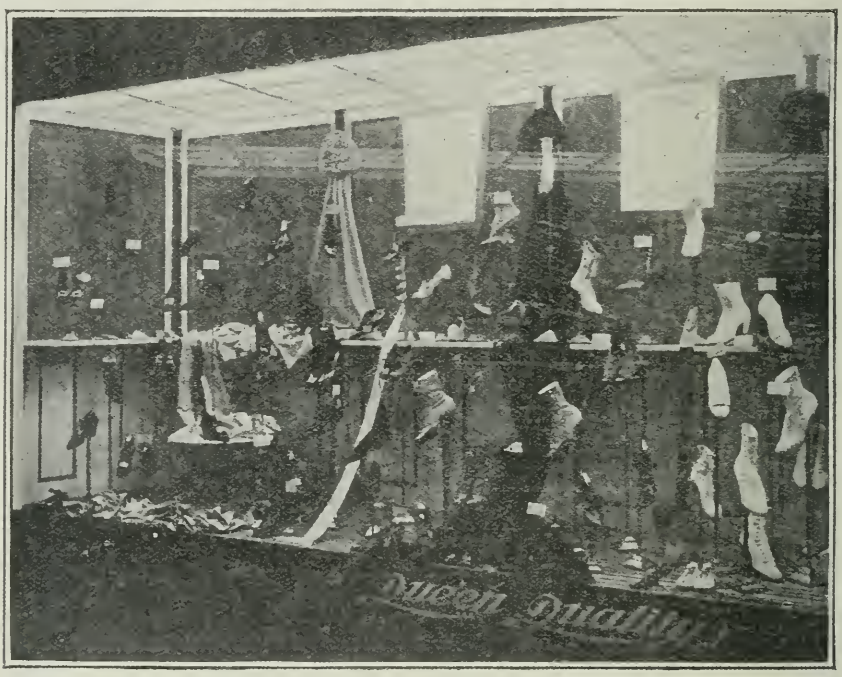


FIG. 6.—A well-lighted window—the detail splendid.

The average effect of reflection from the plate-glass window itself on the illumination is inconsiderable. The "outlined window" is a very common form of lighting; these are merely display windows, whose aim is simply to attract attention to the goods as a whole, and not intended to illuminate them. There is a prevalent idea that the light units should taper off towards one end or other of the window to produce the shadows of exhibits in their proper relation, but Mr. Henninger holds that proper contrast between

articles on display and the background, as well as a proper harmony or contrast of articles themselves, together with well-diffused illumination, are of far more importance.

In designing illumination two main objects must be held in mind: (1) the intensity of illumination must be sufficiently high (2) the diffusion of light good. The most satisfactory results are obtained when the light is from above and in front. Rarely need the angle of "light throw" cover an angle of more than 90 degs., measured in a plane perpendicular to the plate glass of the window and perpendicular to the floor of the same. Many lamp manufacturers seem to be ignorant of this, for most of their reflectors project too much light towards the top of the window. Quite a number of them have unnecessarily weird curves. The mirrored glass reflector is very efficient; it is opaque and encloses the lamp: no light, therefore, is lost in the upper part of the window. The clear, prismatic reflector is of good, scientific design and cheap, but being translucent, dissipates some of the light to the upper part of the window and ceiling, where it is not required; it must frequently be removed and cleaned on account of the prisms. Steel, cone-shaped reflectors lined with mirrored glass strips are fairly efficient while new, but soon become inefficient and require frequent cleaning on account of the many joints in the glass. Opal glassware gives good æsthetic results, but is not efficient. The metal trough reflectors are popular, owing to their cheapness and the ease with which they are installed. They are lined either with opal glass or corrugated mirrored glass; the initial efficiency of the mirrored glass is higher than that of the opal glass, but owing to the action of the air and heat the mercury backing turns brown and peels at the edges. Since this reflector does not enclose the lamp, a considerable portion of the filament is exposed, and much light is therefore wasted.

For a great many windows the ideal arrangement for illumination is to place the concentrating units in a vertical position in the upper front edge of the window. Often two reflectors are necessary: one to throw the light down, and another to throw the light back. It is desirable to have a broad throw of light lengthwise to the window, as it tends to produce good diffusion.

A large number of small light units is preferable to a small number of large units. The cost of installation of the former is large but the latter system is only suitable for horizontal articles, and has the further disadvantage of producing insufficient and unsightly illumination when one of the lamps fails.

There is some question as to what should be considered the plane of illumination in a show window. Figs.

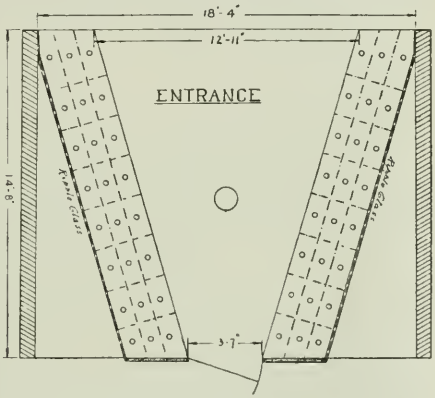


FIG. 7.—Plan of converging windows showing position of lighting units.

1–5 are polar curves suitable for different sizes of window. Planes A and B represent two possible extremes. Large objects such as dress forms may be set up vertically in a window, but in general the plane of dress will be somewhere between these limits. Fig. 1 represents a very large window with a high ceiling; Fig. 2 a large show-window with a low ceiling; Fig. 3 a narrow show-window with a high ceiling; Fig. 4 a narrow show-window with a low ceiling; and Fig. 5 a narrow show-window with a wall case.

High, narrow windows are difficult to illuminate; they should be lighted from the bottom as well as from the top, or they may be divided into fairly narrow vertical compartments, and illumined from the sides of these.

Sometimes the less economical carbon filament lamps are still used in preference to the usual tungsten filament lamp, on account of its soft and mellow light.

Fig. 6 shows a very interesting example of window lighting in Cleveland, U.S.A. This store has a converging front, the vestibule being widest at the street side and narrowest at the store end. The windows are set obliquely with regard to the sidewalk; they are about 7 ft. high, 16 ft. long, and 3 ft. in depth. Each window is divided into twenty-four 1-ft. by 2-ft. panels, each panel recessed in the form of a rectangular box about 1 ft. in depth and painted flat white. In the centre of each of these recesses is placed a 40-watt bowl-frosted tungsten lamp. Fig. 7 shows the plan of lighting. The energy consumed is, therefore, about 3 watts per cubic foot of space in the window. With an efficient reflector an illumination intensity of about 60 to 80 foot-candles might be obtained. Actual illuminometer measurements show that the average intensity of illumination measured in a plane 18 in. above the window floor is 16·3 foot-candles. Mr. Henninger therefore considers that the efficiency is not good, but the diffusion of light is excellent. There is scarcely a shadow anywhere.

[It may be interesting to recall that, in the case of the windows at Harrod's Stores, described last year, where the illumination was of the same order, the wattage in the shallow windows works out to about 1·25 watts per cubic foot.]

The Lighting of the London and North-Western Railway Hotel, Lime Street, Liverpool.

By An Engineering Correspondent.

The accompanying illustration, obtained solely with the aid of artificial light, show a portion of the smoking room at the well-known North-Western Hotel, Lime Street, Liverpool. The points of interest in connexion with the lighting of this room are as follows.

The old installation consisted of a large number of tungsten lamps equipped with fancy glass shades, and suspended at a height of only 8 ft. above the floor level. The energy consumption was about 1,030 watts, with a resultant average illumination of about 1 foot-candle on the horizontal plane 2 ft. 6 in. above the floor level, although in one place the value was as much as 5 foot-candles, showing a great lack of uniformity.

The length of the room is 31 ft. 9 in., the width 29 ft., and the height 18 ft., from which it will be gathered that for the energy consumption employed the illumination was not good. Moreover, the light units, being hung so low, looked out of place in this comparatively large room, and harmful shadows were produced in many places. This was particularly the case when the newsboard, which can be seen in one of the illustrations, was approached. The worst feature, however, was the presence of "glare," owing to the inefficient screening of the lamp filaments and their low position.

A higher average standard of illumination was recommended and agreed to by the authorities, and it was also decided that the new scheme should distribute the illumination more evenly. Further, it was suggested that means should be taken to avoid dense shadows, or any shadow of an intensity exceeding 20 per cent in a harmful direction. The problem was carefully studied with a view to determining the best number,

arrangement, and position of the light units, with the least possible alteration to existing conditions. After consultation, it was decided to install 100 watt pip obscured tungsten lamps and I type Holophane reflectors, spaced, so far as possible, in accordance with the published rules. Care was taken to place them at such a height as would avoid inconvenient shadows being cast on the working plane, or on the approximately vertical surface of the news racks.

Seventeen points were installed, making a total energy consumption for the floor area of 928 sq. ft. of 1,156 watts. This is equivalent to 1·2 watts per sq. ft. The height of the light units above the floor level is now 12 ft. The whole room is brilliantly lighted, the value of illumination on the working plane now being over 3 foot-candles, while "glare" has been entirely eliminated by raising the light units and enclosing the whole of the bare filament by employing the correct size of reflectors, and pip obscuring the lamps.

The present system unquestionably improves the appearance of the room, although it appears that the initial cost of the installation has been comparatively small.

FIG. 1.—A view of the Smoking-room at the London and North-Western Railway Hotel, Lime Street, Liverpool, lighted by Tungsten lamps and Holophane reflectors.
(Photo taken entirely by artificial light.)

Since the accompanying illustrations were taken, the large lounge in this hotel has also been equipped with Holophane, but in this case central Stiletto Reflector Bowl units and Residence Reflectors on the wall brackets have been employed, these types of glassware being more suitable for the purpose in view.

A Modern Semi-Indirect Gas Lighting Installation.

SEMI-INDIRECT gas lighting is evidently receiving notice in the States. The following illustrations, taken from an article by Mr. R. F. Pierce in *Good Lighting* (the Illuminating Engineer of New York) for October, 1912, refer to an installation of white glass bowl semi-indirect fittings. These are equipped with a cluster of inverted mantles. Figs. 1 and 2 show a very simple form of design. Fig. 3 represents a living-room with a slightly more elaborate fitting. A test of illumination was carried out in this room. The fittings contained two inverted gas lamps. A set of readings was first taken with both lamps on; one lamp was then turned out, and the effect of the resulting illumination noted. It was possible to read comfortably in any part of the room, and the music at the piano, 8 ft. from the light source, could be made out with ease. The normal illumination on the music at the piano was 2 foot-candles (2 lumens per square foot), with two lamps burning; but apparently 1 foot-candle, obtained with only one light, was considered sufficient. The effectiveness of this low degree of illumination was considered to be largely due to the very low brilliancy and large area occupied by the light source. The illumination immediately below the fitting—30 in. above the floor level—was 11 foot-candles. This high local intensity is very convenient for those engaged in any sort of work requiring close vision.

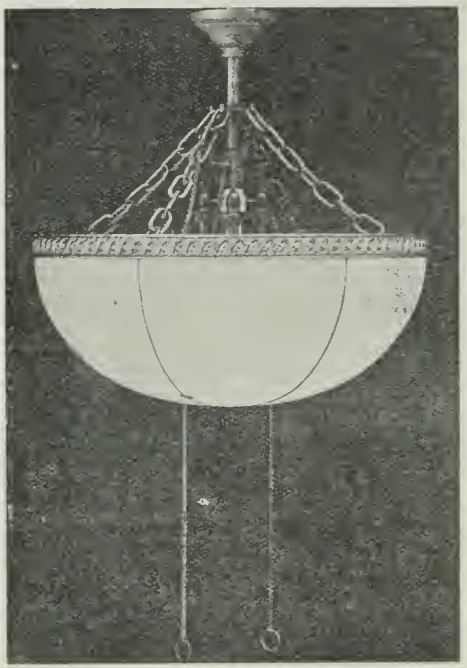


FIG. 1.—Semi-indirect gas fixture.

Fig. 4 shows a dining-room with a similar fitting, but of different shape.

Much depends upon the quality of glass used, the form of bowl, and its position relative to the light source.

To obtain warm tones it is better to use amber mantles than to resort to tinted glass bowls whose diffusing and relative qualities are not so good. Ordinary art glass may be used for ordinary purposes so long as the body of the bowl is kept free for reflecting purposes.

Though the efficiency in the indirect system is admittedly not so high as that of direct lighting, it is now being used to a great extent on account of its attractive appearance. An important feature, besides the effective distribution of light, is the ornamental appearance of the fixture itself. A very fine effect can be received from moulded diffusing glass of the variety shown in these illustrations, and the mild luminosity of the bowl, seen by transmitted light, is claimed to remove any impression of "flatness" in the system.

From the business standpoint it is worthy of remark that work of this kind, in which the artistic element plays a part, is exceptionally lucrative and less subject to competition.

FIG. 2.—Drawing-room lighted by semi-indirect gas fitting.

FIG. 3.—Show-room with semi-indirect gas light fittings installed.

Luminous Airship Signals.

A RECENT article in the *Deutsche Luftfahrer Zeitschrift* gives an interesting account of a new form of luminous signals for airships. Germany in 1909 was the first country to adopt the Frankenberg system of indicating

FIG. 1.—Letter outlined in Holophane units, serving as an indication to aviators.

their whereabouts to airships by certain letters, marked out in bright points on convenient buildings, and of sufficient size to be seen even by aviators at a considerable height. Silvered glass spheres have sometimes been used for this purpose. Some account of the use of such signs in Paris was given in *The Illuminating Engineer* last year.*

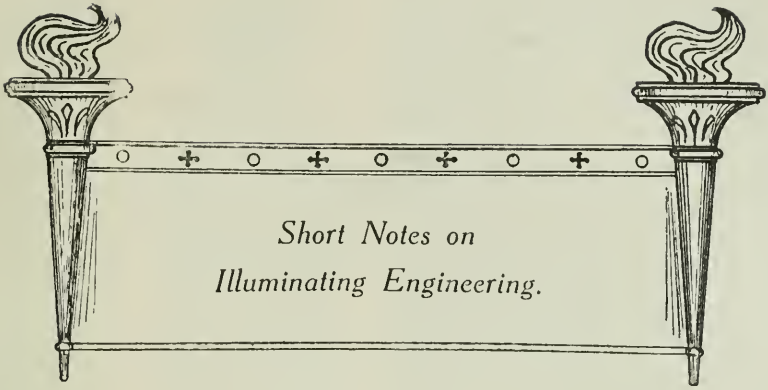
The ideal solution of the problem would involve the use of signs which, besides being visible by day, should be luminous by night. The *Deutsche Luftfahrer Zeitschrift* states that Herr M. Peschke, of the German Holophane Co., has devised a method of doing this by the aid of Holophane prisms. Fig. 1 is a view of a letter made out in this way. Fig. 2 illustrates its use on the roof of a house at the flying ground at Johannisthal. The units outlining the letter, each consist of two parts. There is an inner reflector with radial prisms, so as to concentrate the light and appear highly luminous by day; and in front of this a clear glass hemisphere, having reflecting prisms on the inner side, but a smooth exterior (which, of course, does not collect dust). This serves to collect light striking the glass from a sideways direction, so that the unit appears quite bright, both in sunshine and in cloudy weather. Moreover, each unit may contain a metal filament lamp, and will therefore have the requisite brightness by night.

In Fig. 2 a second method of dealing with the problem is also shown. There are marked out on the roof black letters (MFJ), 2 metres long on a yellow ground. These letters are illuminated in night time by two tungsten lamps in Holophane steel reflectors, the reflectors being selected with a view to producing a sufficiently powerful and even illumination over the letters.

FIG. 2.—Illuminated characters for the guidance of aviators at an Aerodrome in Germany.

Experience has shown that the characters should not be less than 20 cms. broad, and 1·5 metres high. They can then be perceived at a height of 800 metres, and even when the aviator is travelling at 80 kilometres per hour.

* *Illum. Eng.*, Lond., vol. v., 1912, p. 395.



LIGHTING AND ARCHITECTURE.

In a recent paper W. Basset Jones discusses the bearing of artificial light on the architectural appearance of decorative interiors.* Rooms lighted artificially are apt to appear quite different from what they do in the daytime ; it is often desirable to illuminate a moulded ceiling, but one has to be careful to avoid "reversed shadows" (*i.e.*, parts which by daylight appear *light*, looking dark and *vice versa*). This difference in appearance is illustrated in the accompanying illustration. Moreover, a strong light on the ceiling and subdued brightness below may disturb the architectural balance, and take away that impression of solidity which a well-designed scheme should possess. Sometimes this tendency can be counteracted by a graded colour scheme, a gradual change from yellow to white light giving an effect analogous to a change in brightness. It may also be necessary to relieve the monotonous tone in the lower parts of the room by the cunning use of well-shaded local light and trough reflectors.

In all such cases a balance must be struck between practical and decorative requirements ; the best plan is to work out two distinct schemes satisfying these respective requirements, and then to study how they can best be combined.

* Paper read before the Amer. Inst. of Elec. Engineers, June 26th., 1912.

INSUFFICIENT LIGHT CAUSES FATAL ACCIDENT.

The death of Frederick Edward Good, a scene-shifter at the Palladium Theatre, who fell down a lift shaft while at work beneath the stage on Saturday afternoon, was the subject of an inquest by the Westminster coroner yesterday.

The evidence showed that the place was not brilliantly lit, and that there was no rail round the hole, in which water had accumulated. His fellow-workmen heard a thud and a splash, and found that Good had disappeared. He was got up dead by means of a rope and ladder.

The jury returned a verdict of "Accidental Death," with a rider recommending additional light and a rail.—*From the 'Daily Mail' of February 27th*, 1913.

SUBMARINE LIGHTS ON THE CHICAGO RIVER.

Accidents on the Chicago River are only too frequent. The River Police there have recently launched a motor boat equipped with a submarine light to aid them in their task of recovering the bodies of the drowned. This lamp consists of a cylindrical tungsten bulb, whose light, refracted through a heavy triangular prism of glass, is said to be of such intensity that the bed of this not over-clean river may be plainly visible to a depth of from 18 ft. to 20 ft., and it will partially illumine to a depth ranging from 20 ft. to 30 ft.

Edison Electric Safety Lamp.

We note from *The Electric World* that the American Museum of Safety in New York has awarded the Rathenau Gold Medal to Mr. Edison for his Electric Safety Lamp. The lamp is connected to the battery by flex and can be conveniently mounted on the cap of the miner. The battery is strapped to his waist in the manner shown in the illustration. The apparatus weighs about 2 lbs., is about 5 in. wide and 4·5 in. high. The battery has an E.M.F. of 2·4 volts, and will give 4 ampere-hours. The tungsten lamp is rated at 2 candle-power.

Gas Watch Fires at the Funeral of the late Emperor of Japan.

It is said that the watch fires at the funeral of the late Emperor of Japan, apart from their historical significance were a very impressive sight. These were not incandescent lamps, but open gas flames reaching 3 ft. high. The gas was supplied by the Tokyo Gas Company in special mains measuring some 3,090 ft. in length. There were forty of these fires, each of 700 candle-power, contained in a cast-iron vessel, supported between three cryptomeria poles 10 ft. high, the top ends meeting each other and the bases stretching apart forming a triangle. They were stationed on either side of the road at distances of about 60 ft.

Minor gas watch fires were seen in several other streets; thus in the broad street from Tokyo municipal office to the gate of Babasaki in front of the Palace, and on the one side of the tramcar lines before the outer moat in the right hand direction, from the Tokyo Chamber of Commerce to the Imperial Theatre about thirty in number, the same in shape and construction as those in use at the great shrine of Tse and other deities.

LIGHT: THE MODERN GAOLER.

In a recent number of *The Edison Monthly* reference is made to a striking illustration of the value of good illumination to the police. At the Tombs Prison in New York two important prisoners succeeded in escaping during the last few months. It is something of a puzzle how the men were able not only to cross the yard at night, but also to scale the high wall without being seen; but it is thought that this was partly due to the comparative darkness of the surroundings. Had the yard been brilliantly lighted the presence of the men would probably have been detected.

As a result the lighting has been remodelled, and the yard is now stated to be "as bright as daylight." The problem of escaping has now become more formidable, and will present considerable difficulties to prisoners in future.

AN ELECTRICALLY LIGHTED BALLOON.

THE picture shows a novel advertisement recently adopted in New York City and described in *The Electrical World*. It consists of a captive balloon lighted from within by a 500 watt tungsten lamp, and the envelope of the balloon is said to form an excellent diffusing surface. The illuminated sphere is about 20 ft. in diameter, and is a prominent feature, visible at a considerable distance. By means of an anchor cable and reel the balloon can be raised or lowered, but is ordinarily suspended at a height of 500 ft., at which height it is a very conspicuous object.

Modern Illuminants and Effective Shading.

A RECENT number of *Public Health* contained a paper read by Dr. Meredith Young, Medical Officer of Health for Cheshire. Dr. Young pointed out the increasing brilliancy of modern illuminants and the need for care in their use. He remarks :—

"With the advancement of modern science we have been brought under very trying conditions in the matter of *artificial light*, and it is distinctly questionable whether our eyes have been educated up to such a point that they can face most of these new lights unless very careful shading and screening be adopted.

"Those of us who are using electric light habitually know by experience, I fancy, that the effects of its glare are apt to be most irritating. Why is this ? Is it because we have to concentrate our vision on a part which is adequately illuminated and divert it from a part which is inadequately or too brilliantly illuminated, and that the effort becomes exhausting after a short while ? Or is it a mere tiring effect due to the impaction of energy on a part of the retina which, having no work to do, wants to remain quiescent for the time being ? Or is it a more direct effect on the retina or optic disc due to over-stimulation or irritation caused by the high-power rays of the light ? I am inclined somewhat strongly to the last-named view, for I imagine that education and adaptation of the eye would at this stage of our evolution render the first two factors of comparative unimportance.

Even Mr. Samuel Pepys, writing in 1667 (February 16th), makes the following sage statement : "My eyes mighty bad with the light of the candles last night, which was so great as to make my eyes sore all this day, and do teach me, by a manifest experiment, *that it is only too much light that do make my eyes sore.*"

Publications Received.

National Physical Laboratory, Report for 1912.—The Report of the Executive Committee deals with the considerable extensions of the work of the Laboratory, including the new buildings for the section of Metallurgy and Metallurgical Chemistry, Optics, and Administration. These were opened by the Right Hon. A. J. Balfour on Thursday, June 26th. A considerable amount of work has also been done in the form of experiments in naval architecture, aeronautics, electrical and high temperature measurements, and meteorological work.

In the photometric section the experiments with tungsten filament standards give good results, and it is interesting to note that the unit of light is considered to be maintained with a constancy within 0·1 per cent. Tests are being made on a series of tungsten lamps giving light of graded hue with a view to facilitating the photometry of lights that differ in colour. Experiments have also been conducted on the visibility of distant lights, and ships' navigation lights, which are embodied in a Report presented to the Board of Trade this year.

Die Gasglühlichtbeleuchtung. By Dr. C. R. Böhm. 62 pp., 26 Illustrations. (Charlottenburg, Gustav. Heydenreich.)—A short summary of the development of incandescent gas lighting. The book reviews the introduction of inverted mantles, high candle-power low-pressure lamps, and high-pressure lighting, and is illustrated by views of modern types of lamps. An interesting appendix tabulates Monasch's figures for the specific consumption per lux per square metre illuminated of various methods of lighting.

Die Beleuchtung von Eisenbahn-Personenwagen. By Dr. M. Buttner. (Berlin, Julius Springer.)—A work containing a concise summary of methods of lighting railway carriages. Second edition, 1912, 235 pages, 108 illustrations.

Ship Wiring and Fitting. By T. M. Johnston. (London, Constable & Co., 1/- net. —A handy little book (77 pages, 47 illustrations), forming one of the series of "Electrical Installation Manuals." The instructions and diagrams are clear and concise. Most of the information bears on wiring, but there is also a section—which we should like to see somewhat extended—dealing with lamps and fixtures. A few simple suggestions regarding the arrangement and shading of lamps with a view to getting good illumination would be welcome.

Veränderungen und Schädingen des Auges durch Licht—Fluorescence of the Eye—Gefärbte Gläser als Jagd-, Schnee-, und Schutzbrillen—Apparat zur Beobachtung der Fluorescenz am eigenen Auge, &c. By Dr. F. Schanz. (Dresden.)—Describes some experiments on the effect of ultra violet rays on the eye, in exciting fluorescence and diminishing acuteness of vision; particulars of eye-glasses screening the eye from these rays.

Notes on the Design and Economy of Diesel Oil Engines. By Capt. H. Riall Sankey, R.E., M.Inst.C.E. (Paper read before the Association of Engineers-in-Charge, April 9th, 1913.)

New Visual Phenomena. By F. W. Edridge Green. ('Jour. of Physiology,' Vol. XLV., Nos. 1 and 2, Aug. 2nd, 1912.)—An interesting paper, endeavouring to show that many complex phenomena met with in connexion with colour photometry (Purkinje effect, recurrent image, &c.) can be explained on the basis of the action of the photo-chemical pigment, believed to exist in the spaces between the cones in the retina of the human eye.

The Simple Character of the Yellow Sensation. By F. W. Edridge Green. ('Phys. Proceedings.' March 15th, 1913.)

A New Differential Watt-per-Candle Meter. By Dr. E. P. Hyde. (Reprinted from *The Elec. Review and Western Electrician*, Feb. 1st, 1913.)

A Precision Photometer Bench and Accessories. By E. P. Hyde and F. E. Cady. (Reprinted from *The Elec. Review and Western Electrician*, Nov. 16th, 1912.)

Die Osram-Drahtlampe. By H. Remané. (Reprint from *Die Welt der Technik*, No. 7, pp. 130–134, 1913.)

Report of the Committee of the American Illuminating Engineering Society on Nomenclature and Standards. Part II. *Proposed Definition.* (*Transactions*, Vol. VII., No. 9, December, 1912.)

British Association for the Advancement of Science.—The Annual Meeting is to be held in Birmingham, Sept. 10th–17th, 1913, under the Presidency of Sir Oliver Lodge (Principal of Birmingham University). Further particulars can be obtained on application to the Secretary of the Association at Burlington House, London.

Review of the Technical Press.

ILLUMINATION AND PHOTOMETRY.

Dr. Louis Bell contributes two interesting articles to *The Electrical World*. The first of these deals with the **preservation** of silvered mirrors. Instances are given of mirrors whose reflecting power has diminished quite appreciably in the course of time, even though the silvered surface was apparently well protected from the air. Various devices are described for securing greater permanency such as coating the back of the mirror with collodion. A curve is given showing how the co-efficient of reflection varies throughout the spectrum, being very nearly constant for the visible rays but diminishing in the ultra violet.

The second article by Bell describes some investigations of Dr. F. H. Verhoeff at the Massachussetts Eye Hospital, carried out during the past year. The **effects of Light, Heat, and Ultra-Violet Rays on the Eye** were all studied. It was shown that very powerful ultra-violet light does have a "stippling" effect on the eye-lense, causing a slight haziness of vision, which, however, passes off with rest. It is shown that a flux of energy equivalent to 15×10^5 ergs per second would have a distinct effect in about five minutes; but the eye could probably be exposed to any ordinary source of light at a distance of $2\frac{1}{2}$ metres for two hours before this effect was produced. The author therefore concludes that most artificial illuminants can have little prejudicial effect on the eyes provided reasonable precautions are taken.

The question of the **Chemical Effects of Ultra-Violet** Rays is also considered in an article by Schwarz and Aumann (*J. f. G.*, May 31st). These authors deal with the use of the rays for water sterilization. How is the efficiency of artificial illuminants in this respect to be tested? There are various methods such as the darkening in a certain time of a standard sample of sensitive paper, and the influence on various chemical substances, such as hydrogen peroxide and paraphenylemediamine. But these tests seem to indicate the chemical activity of the rays rather than their effect on bacteria, and might fail to differentiate between various qualities of ultra-violet radiation.

Cravath in *The Electrical World* (May 31st and June 17th) points out the great part played by **contrast in illumination**; provided the contrast between a source and its surroundings is not too great one can bear quite a high brightness without feeling the disagreeable sensation of glare.

In a letter Cravath also refers to the effect on the audience of white diagrams and lantern screens. In one case the lighting effects in a hall were found to be distinctly trying, even though the lights themselves were quite out of sight. This was traced to the fact that the light fell on a white screen behind the platform. Continually gazing at this uniform bright surface was fatiguing. In addition it made it difficult for the faces of people on the platform, silhouetted against this background, to be clearly seen.

Among the editorials dealing with matters of illumination, special reference should be made to that in *The Journal of Gaslighting* (June 10th), in which the progress of the Illuminating Engineering movement in England is surveyed, and its value to the gas industry fully acknowledged.

An article by Schanzer (*Elek. u. Masch.*, May 25th), describes a **New Form of Photometer** for measuring the distribution of light and mean spherical candle-power. The chief feature of this apparatus is the use of an adjustable arm coupled to the photometric bench, and carrying at its extremity a mirror. This arm can be moved round the source to be tested, and by means of a second mirror and a system of lenses, an image of the light source is located over the

zero point of the bench. In making measurements the distance of the source from the photometer is not altered, and its dimensions are immaterial. For very powerful sources a mat aluminium mirror is sometimes used.

ELECTRIC LIGHTING.

The Electrical World and Western Electrician (May 31st), contains a general article analysing tendencies in electric lighting. Dr. B. Monasch (*E. T. Z.*, June 5th), also contributes a general article summarizing **Progress in Electric Illuminants.** The developments that claim attention are those recently introduced into the Mercury lamp. For example, the construction of lamps for high voltages, and for use on an alternating current, and the Cadmium Mercury lamp invented by Wolfke.

Weintraub (*Elec. World*, May 10th), describes **A New Quartz Tube Mercury Vapour Lamp**, using solid tungsten anodes. This is said to be favourable to the life of the lamp, and it has been found possible to seal the tungsten electrode into the quartz glass instead of its being ground in, as is necessary when a platinum conductor is used. Some **Developments of the Moore Tube** are described in the *Zeitschrift für Beleuchtungswesen* (May 30th). The author describes a method of winding the transformer for a three-phase installation so as to enable each of the secondary phases to be used quite separately. There is also a method of exaggerating the secondary pressure by means of a spark gap and condenser, giving a resonance effect. It is said that when a very high P.D. indeed, is used, electrodes *outside* the tube are sufficient, and the absorption of gas inside the tube prevented. Should this be found practicable the special valve admitting gas to the tube at regular intervals would become unnecessary.

Recent numbers of *The Electrician* describe various novelties in electric lighting such as the "Dim-a-lite" switch for electric lamps, which introduces a resistance into the circuit and enables the light to be gradually diminished. Another article deals with the "Oriona" lamp. This is a type of tungsten lamp with a filament suspended horizontally, so as to give a strong illumination underneath the lamp, and it is also stated to be stronger.

A. Strauss (*E.T.Z.*, May 22nd), describes the **Public Lighting of Dresden**, where metal filament lamps are now being very generally used in the side streets. By the substitution of such lamps in place of ordinary white arc lamps, double the illumination, and a saving of 25 per cent were secured. It is interesting to note that a friendly working relation between the gas and electric interests exists in this town, and there is no difficulty in deciding their respective fields of action. Both methods are used. In the outskirts of Dresden (where it would not be worth while to lay gas or electric mains), and for country roads and footpaths, oil lamps are frequently used.

GAS, OIL, AND ACETYLENE LIGHTING.

There is not a great deal to be recorded in this section. The British gas journals are taken up to a great extent with the account of the Annual Meeting of the Institution of Gas Engineers. The papers presented do not deal with lighting.

G. B. Barham (*G.W.*, May 24th), discusses **Incandescent Lighting for Railway Carriages,** and gives some figures for the costs of various methods. On the G.W.R., for example, 20 candle-power units consuming 0·65 cubic feet per hour are very commonly used. Originally a great deal of trouble was experienced in finding mantles that would stand the shock of railway travelling, but this defect has been largely overcome. Mantles will now last 350-375 hours, and on smooth running main lines more favourable results may be expected.

W. A. Morris (*Gas Age*, May 15th), contributes an article on **Domestic Lighting,** which is interesting for the illustrations of attractive gas fixtures. There is doubtless a great deal more to be done in this direction in England.

The acetylene journals contain an account of the papers read at the recent International Congress in Rome. Many of these were devoted to modern developments in the use of acetylene in navigation, special reference being made to the lighting at the entrance of the Panama Canal.

In the *Revue des Éclairages* (May 31st), there is an account of the Féry Acetylene Standard of Light which, however, does not as yet appear to have been used in practice to any great extent. The same journal contains an interesting account of a "travelling church" in the United States, built and furnished in the Gothic style, and lighted entirely by acetylene.

List of References:—

ILLUMINATION AND PHOTOMETRY.

Bell, L. Silvered Mirrors and their Preservation (*Elec. World*, May 24).
The Effect of Radiation on the Eye (*Elec. World.*, May 24).
Coblentz, W. W. The Construction of Thermopiles for Monochromatic Illuminators (*Jour. Frank. Inst.*, May).
Cravath, J. R. Contrast in Illumination (*Elec. World*, June 7).
White Screens before Audiences (*Elec. World*, May 31).
Editorial. The Gas Industry and Illumination (*J.G.L.*, June 10).
"White Way" Lighting (*Elec. World*, May 24).
The Union of Science and Practice in Investigation (*J.G.L.*, May 20).
Rose, S. L. E., and Mahan, H. E. Measurement of Illumination (*General Elec. Review*, May).
Schanzer, M. Neues Photometer zur Messung der räumlichen Lichtverteilung (*Elek. u. Masch.*, May 25).
Schwarz, L., and Aumann. Ueber Wasserbehandlung mit ultravioletten Strahlen (*J.f.G.*, May 31).
Voege, W. Die Strahlung unserer kunstlichen Lichtquellen im Vergleich zu einander und zum Tageslicht, *continuation* (*Licht u. Lampe*, May 22).
Lighting of a Department Store (*Elec. World*, May 24).
Illumination at the Panama Exposition (*Elec. Rev.*, U.S.A., May 17; *Elec. World*, May 17).
Photometry and Streetlighting (*J.G.L.*, June 3).
Light Adorable, (*Edison Monthly*, May, 1913).
Westminster Abbey's New Lighting (*Elec. Times*, May 22).

ELECTRIC LIGHTING.

Editorial. Electric Lighting for Motor Cars (*Elec. Rev.*, May 30).
Drawn Tungsten Filaments (*Elec. World*, May 17).
De Kermond. La "Dim-a-lite" (*Electricien*, May 24).
Lampe Oriona (*Electricien*, June 7).
Monasch, B. Die Neuen elektrischen Lichtquellen (*E.T.Z.*, June 5).
Strauss, A. Beleuchtung der Stadt Dresden (*E.T.Z.*, May 22, 1913).
Weintraub, E. Development of a New Quartz Tube Mercury Arc Lamp (*Elec. World*, May 10).
La "Lumière froide" de M. Dussand (*Rev. Electrique*, May 16).
Some Tendencies in Electric Lighting (*Elec. Rev. and West. Elec.*, May 31).
Fortschritte in der Beleuchtung mit Moore-Licht (*Z.f.B.*, May 30).

GAS, OIL, AND ACETYLENE LIGHTING.

Barham, G. B. Incandescent Gas Lighting for Railway Carriages (*G.W.*, May 24).
Morris, W. A. Domestic Lighting (*Gas Age*, May 15).
Seager, J. A. Automatic Lighting and Extinguishing of Gas Lamps (*Am. Gaslight Journal*, May 26).
Indirekte und halbindirekte Beleuchtung (*Z.f.B.*, May 20).
Effect and Convenience in Gas Fittings (*J.G.L.*, June 3).
L'Étalon Fèry à Acetylene (*Rev. des Eclairages*, May 31).
Acetylene Lighting: Some Papers read at the International Congress in Rome May 31).
Exposition en Angleterre de Lampes et Appareils Portatifs (*Rev. des Eclairages, Acetylene*, May).
Une Église Ambulante éclairée à Acétylène (*Rev. des Eclairages*, May 31).

CONTRACTIONS USED.

E. T. Z.—*Elektrotechnische Zeitschrift.*
Elek. u. Masch.—*Elektrotechnik und Maschinenbau.*
G. W.—*Gas World.*
J. f. G.—*Journal für Gasbeleuchtung.*
J. G. L.—*Journal of Gaslighting.*
Z. f. B.—*Zeitschrift für Beleuchtungswesen.*

TRADE NOTES.

[At the request of many of our readers we have extended the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

Merits of Tantalum and Wotan Lamps.

A Novel Cinematograph Display.

At one of the Cinema theatres, in Dalston, an interesting cinematograph display was recently arranged by Messrs. Siemens Bros. Films were shown illustrating all stages in the manufacture of tantalum lamps, and the subsequent dispatching of them from the factory. An enterprising feature was the portrayal of family life, and a series of incidents showing the value of good illumination in the home.

Messrs. Siemens Bros. Dynamo Works, Ltd., also inform us that a contract has been entered into with the Great Northern Railway for the supply of drawn wire metal filament and carbon filament lamps during the ensuing twelve months, and that a contract for the supply of standard carbon filament lamps has been obtained from the War Office.

Contracts for Tantalum traction lamps have also been entered into with the Royal Mail Steam Packet Co. and the Rochdale Corporation Tramways. Finally a very large order for Wotan lamps has been received from a large town in S. America.

The Benjamin Electric, Ltd., request us to mention that the Accounts and Order Departments are now managed at the company's works at 1A, Rosebery Avenue, E.C. (Tel. No. City 2407).

The Sales Office and Showrooms are still at 117, Victoria Street, S.W., where all inquiries should be addressed.

We are also informed that Mr. Guy Campbell, the Sales Manager, has joined the Board of Directors of the Company as Managing Director.

The Benjamin Electric Manufacturing Co. of Chicago, Ill., U.S.A., and the Benjamin Electric Manufacturing Co. of Canada, Ltd., have large factories for the manufacture of Benjamin electric lighting specialities for sale in their respective countries, while the Benjamin Electric, Ltd., manufacture at their London factory the material for the English and Colonial markets.

The "Keith Light."

The James Keith & Blackman Co., Ltd. (27, Farringdon Avenue, London, E.C.), have issued an attractive little booklet describing the Keith light. The pamphlet is illustrated by a series of illustrations of streets and factories lighted by high-pressure gas, the photographs being taken by artificial light. Special reference is made to "Parade, or Scale Lighting," which has been such a feature of high-pressure gas. In conclusion a few illustrations of typical high-pressure units are given.

Poplar Electricity Works Extensions.

Official Opening, June 6th.

We have received a copy of the souvenir booklet issued at the opening of these works on June 6th. It is attractively got up, and contains a history of the station from its inception in 1900 prepared by the chairman of the Electricity Committee, Councillor H. R. Barge.

Cinematograph Specialities.

The Tress Co. (4, Rathbone Place, London, W.) send us their latest catalogue of cinematograph specialities. Illuminated and bead signs, and screen transparencies form a special feature, and particulars are also given of some photographic accessories, such as film enlargers and portable lamps for portrait and cinematograph work.

INDEX, July, 1913.

Subjects.	Authors.	PAGE.
Editorial	L. Gaster	351
Illuminating Engineering, Short Notes on		397
Illuminating Engineering Society:—		
Account of Annual Meeting		355
Report of Council for the Past Session		357
Interim Report on School Lighting		364
,, ,, ,, Library ,,		366
List of Members		368
Indirect Gas Lighting Installation, An		394
Luminous Airship Signals		396
Publications Received		400
Railway Hotel, Lighting of a	An Engineering Correspondent	392
Review of Technical Press		401
Shop Lighting, Some Notes on	J. G. Heninger	38
Trade Notes		40

In our last number some particulars of the B.T.H. "X-ray" reflectors for shop-window lighting were given. The above illustration shows the effective lighting of a window by a row of these reflectors concealed behind the facia. The lights are completely concealed from the eyes, and a brilliant illumination shed on the goods.

THE

Holophane Lumeter.

The simple, portable, and accurate apparatus for measuring illumination, surface-brightness, or reflecting power.

Can be carried from place to place with the ease of a small hand camera.

Dimensions only $5\frac{3}{4}'' \times 4\frac{1}{2}'' \times 1\frac{3}{4}''$; case and accumulator supplied.

Measurements from 0·01 to 2000 foot-candles can be made.

Showing general appearance of new model of Holophane Lumeter.
(Dimensions : $5\frac{3}{4}'' \times 4\frac{1}{2}'' \times 1\frac{3}{4}''$.)

The Holophane Lumeter is of value not only to lighting engineers, but to architects, medical officers, factory inspectors, photographers, and many others.

Among the users of this instrument may be mentioned :—

The House of Commons, The Home Office (Factory Dept.), The London County Council, General Post Office, Great Western Railway, L. and S.W. Railway, Underground Railways, The Gas Light & Coke Co , St. James and Pall Mall Electric Supply Co., The Union Electric Co., The British Thomson-Houston Co., &c., &c.

For all particulars apply to

HOLOPHANE LTD.

12, Carteret St., Queen Anne's Gate, S.W.

The ILLUMINATING ENGINEER
ELECTRICITY · ACETYLENE · OIL · GAS
Edited by LEON · GASTER

THE JOURNAL OF SCIENTIFIC
ILLUMINATION.
OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London, 1909.)
ILLUMINATING ENGINEERING PUBLISHING COMPANY, LTD.,
32. VICTORIA STREET, LONDON, S.W.
Tel. No. 5215 Victoria.

EDITORIAL.

The Lighting of Lecture Theatres.

In the last number we published the Interim Report of the Joint Committee on the Artificial Lighting of Schools. In this issue we are publishing two interesting articles, which we have received from Professor Bohle and C. E. Greenslade, the former of the University of Capetown and the latter of the Crawford Technical Institute, Cork, both of whom describe the lighting of lecture theatres in their respective colleges. No doubt the conditions in technical colleges are somewhat different from those in elementary schools for which the report of the Joint Committee was presumably intended. But the main essentials of good lighting are substantially the same in both cases.

It will be admitted that the lighting in engineering institutions and colleges is still often deplorably bad. An enterprising teacher of electrical engineering would naturally make the lighting of his laboratories and lecture theatre the subject of special study, but the subject of engineering is such a vast one that lighting is apt to fall into the background. This is not always the fault of the staff. But surely the illumination at a Technical

Institute should be a model. The Professors have special facilities, and the latest information on the subject is readily available to them; they can often obtain substantial gratuitous help from companies in lighting appliances; and they have at their disposal workshops where new apparatus can be contrived, and students a part of whose education it should be to study such new methods of lighting. But it is, admittedly, often difficult to persuade the authorities that the illumination is an important matter, and to induce them to go to the necessary expense. We hope that the circulation of the reports published in our last number will do something to modify this view.

In the two cases before us the lighting seems to have received special attention. It is surely more than a coincidence that the methods adopted in the lecture theatre at Cork, about which Mr. Greenslade gives definite details, agree so closely with those recommended by the Committee.

The arrangements for lighting the demonstration table and blackboard are particularly interesting. While substantially confirming the suggestions of the Committee the author raises several small points in blackboard lighting which still require to be threshed out. One of these is the inclination at which the light should strike the blackboard surface. This must be considered in securing the avoidance of glare caused by shininess of the board. There is also the additional fact that the fine particles of chalk remaining on its surface after the board has been used for some time are apt to catch the light and impose a kind of "luminous veil" over the writing. This, it appears, is most likely to occur when the rays strike the board very obliquely.

A second interesting question is the upper limit of illumination. It has several times been suggested that in illuminating surfaces to be seen from some distance (such as blackboards, placards, targets in rifle ranges, &c.), the illumination, while sufficient, should not be too high: if the light is excessive there is a kind of spreading effect of the illuminated figures (irradiation), which interferes with distinct vision. At present there do not seem sufficient data available to enable one to state the exact circumstances giving rise to this effect, but the phenomenon certainly ought to be investigated.

We understand that illumination forms an integral part of the instruction both in the Crawford Institute and in Capetown. We shall be interested to hear further particulars of the experiments on illumination undertaken by the students and feel sure that there is a rich field for study in this direction. In the past, there is no doubt, the experiments provided in some laboratories have not been of the most interesting character. Students have been needlessly bored by tedious calculations and troublesome apparatus. Surely in these days of improved illumination photometers it should be possible for them to pass over the initial stages of the work more rapidly and attack practical problems on illumination.

Electricity in Planning and Architectural Design.

The article which we have abstracted from a recent number of the *Journal of the Society of Architects* (see page 433—434) says quite plainly what has often been hinted in these columns—that it is the duty of the architect to interest himself much more closely in problems of illumination. It is very gratifying to find a writer in an architectural journal placing such emphasis on this point.

Everyone will admit that the architecture and planning of many buildings, which have been in the past so vitally affected by daylight, should now be modified to some extent by the provision of artificial illumination. " Light creates the surroundings to a man's eye just as much as nourishment supports man's body." It has much to do with the attractiveness of a building in the night time. No doubt this is not equally true of all buildings, but there are certain cases, notably the design of modern large stores, so ably discussed by Mr. Lanchester a few months ago, in which artificial light should have a vital effect on the design.

The proposed rebuilding of Regent Street is quoted as a case in point. It is remarked that the proposed plans have met with small favour from the shop-keepers of this street, who are averse from the idea of devoting much of the frontage to stone-work—" useless lumps of stone occupying useful space." But it is suggested, why not illuminate these lumps of stone so as to make them striking objects which involuntarily catch the eyes of passers-by? For example, inverted mouldings placed round the base of columns would enable them to be illuminated. Special decorative effects might be arranged for in the galleries and colonnades, &c.

But it is in the interiors of the buildings that the disregard of lighting has most serious results. Several of those who spoke in the discussion of Mr. Lanchester's paper—men whose names are associated with the largest emporiums in London—confirmed this opinion. By the provision of judicious mouldings, recesses and outlets for the lamps at an early stage in the design, the lighting and the style of the interior might be brought into complete harmony and something really striking and effective obained. At present the lighting is an afterthought. The positions of lamps and the nature of the fittings are only determined when the building is actually up and when it has become difficult to scheme out anything really novel and attractive. The right course, as we have said again and again, is for the architects of large buildings to take the lighting engineer into their confidence at an early stage in the proceedings; and not only to take an interest in his work, but to offer suggestions as to how the lighting should be arranged in order to meet both the practical and the architectural needs of the building. This is the age of specialisation, and we feel sure that the architect would lose nothing in dignity by such co-operation.

Scientific Glassware and Illuminating Engineering.

Several recent papers before the Illuminating Engineering Society have demonstrated the important rôle played by scientifically designed shades and reflectors.

Whatever be the problem before us, we find that its solution depends on the choice of the appropriate globe, shade or reflector. Manufacturers now make a special point of producing fittings to meet specific problems. They supply data enabling the contractor to choose the proper pattern of shade and to calculate the resulting illumination. Illuminating glassware, formerly regarded merely as a more or less ornamental accessory, is now designed in accordance with fixed optical laws and with a view to the proper distribution of light.

It will therefore be appreciated that a departure from the guaranteed design is regarded more seriously than it would have been a few years ago. For to-day it is known that even small changes in the design of reflectors, such as are not apparent to the untrained eye, may have a great influence on its performance in practice. No system of glassware would now be considered scientific in design without a guarantee that each individual shade or reflector will give a certain predetermined distribution of light ; without this understanding accurate illuminating engineering would hardly be possible.

As an illustration we may refer to a recent action in the King's Bench Division in which Holophane, Ltd., were concerned. The case arose through the sale as "Holophane," of a certain variety of prismatic glassware the quality of which the Company considered to be inferior. It was urged that the substitution of glassware which did not comply exactly with the data published would be prejudicial to the reputation which the Company had built up, since a unit would no longer give the results anticipated.

As is well known, the Holophane Company were among the earliest pioneering concerns in illuminating engineering. Besides winning well-merited approval from experts in illumination all the world over they have had the unique distinction—(which we believe has not been conferred on any other forms of glassware serving as distributors of light)—of receiving awards from the Franklin Institute and at several International Exhibitions, in recognition of the scientific nature of their products.

In order to give good results prismatic glassware needs to be designed with extreme care. The prisms have to be accurately shaped so that the rays of light may be regularly and uniformly diffused in exactly the predetermined directions, and for which purpose special tools and moulds are necessary. The experience of the last fifteen years justifies the claim that the Holophane Company's Glassware is essentially scientific, and we are glad to see that it is the intention of the Company to keep their high reputation, and congratulate them on the stand they have taken on behalf of scientifically designed glassware.

LEON GASTER.

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of "The Illuminating Engineer."

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

SOME NOTES ON INTERIOR ILLUMINATION.

By Prof. H. Bohle.

[Abstract of a paper read before the Cape Town local section of the Institution of Elec. Engineers, Sept. 4th, 1912.]

With the improvement in the manufacture of incandescent lamps the quantity of light required for comfort has increased to a remarkable extent. Where formerly an illumination of one candle-foot was sufficient, we require nowadays about double this quantity. The table which the writer published on a previous occasion,* and which was considered by a few to give a somewhat excessive illumination, produces to-day no more than the proper requirements. And in some places an even higher illumination is essential in order to recognise the finest details. The table gives figures varying from 32·8 candle-feet for a room with black walls and ceiling to 1·37 candle-feet for a room with white walls and ceiling, showing thus a great divergency.

But there is no doubt that the eye is affected far more by *contrast* than by actual illumination. A room with an average illumination of 3 candle-feet, having dark walls, will look badly illuminated compared with a white room with half the illumination. On the whole it is useless to instal at the present day a greater illumination than given in the above-mentioned table; light would simply be wasted, since the eye is already in full action; only in the case of extreme requirements (for local work and spectacular effect) should the illumination be greater.

Contracton of the Pupil and Fatigue.

An illuminating engineer must satisfy two sciences:—physics and physiology. A lighting installation may be perfect from a physical standpoint and yet be physiologically defective. In other words, *sufficient* light does not always represent a *correct* light. An increase in the intensity may even decrease the quantity of light entering the eye, for a high uniform illumination produces fatigue and causes the pupil aperture to contract. This is especially the case with direct light, which must be averted from the eyes, either by placing it out of the line of vision or by surrounding it with proper globes. The contraction of the pupil aperture takes place when a sudden excess amount of light enters it; whereas fatigue is caused by continued absorption of large quantities of light. Consequently, we should really supply two illuminations; a fairly high one for working purposes, supplying the local illumination, and a considerably lower one for general purposes, which allows the eye to rest from the high intensity, and to recover its increased sensitiveness.

Colour of Light.

The colour of light has an important bearing on the comfort attainable. In

* See the author's book on *Electrical Photometry and Illumination*, page 162 (Ch. Griffin and Co.).

† For further information see author's text book.

the case of a low illumination, the sensitiveness of the eye moves towards the greenish-blue part of the spectrum, so that light rich in these rays, such as given by the Mercury Vapour Lamp, is preferable. Unfortunately, the almost total absence of red rays makes everything look of a ghastly colour. In rooms with light colours, lamps rich in greenish-blue rays are less desirable. Dirt is mostly of a brownish colour, and when the light of a Mercury Vapour Lamp strikes it, it appears practically black. To avoid stains from soiled materials and the sombre appearance of red and brown papers, we should use lamps rich in red rays. This would imply that for indoor lighting the incandescent lamp has many points in its favour.

Uniformity of Illumination and Shadows.

Sharp shadows should always be prevented, but they must not be done away with altogether, as it may then become difficult to distinguish fine details. To see properly so as to recognise fine details it is essential to have different shades. In an Ulbricht Globe Photometer, with an almost perfect diffusion, it would be extremely difficult to distinguish a white sphere from a white disc. In ordinary rooms, however, we cannot easily diffuse the light too much, even if the walls and ceiling are perfectly white; the furniture of the room will usually provide sufficient contrast and a perfect diffusion will not result.

This is well illustrated in Fig. 1, which represents a photograph of the "Common Room" in the New Hiddingh Hall. From Fig. 1, it will be seen that even the finest details of the pictures on the wall are recognisable, and the creases in the trousers of the person sitting at the table. Properly diffused light can be obtained with direct, as well as with indirect light.

There is no doubt that, in order to avoid glare, people have largely gone from the one extreme, namely, direct light in the line of vision, to the other extreme, namely, indirect light. But, indirect lighting is a good deal more expensive than the direct method, since the loss of light is much greater. Where the lights can be placed out of the line of vision, there is no need for installing indirect lighting since almost equally good results may be obtained with the direct method and at a lower cost. The light must, of course, be well distributed, but this is also essential for the indirect method. Shadows should be largely avoided. The sharpness of the shadow depends not only on the type of illumination and the distribution, and the reflective powers of the surroundings, but also upon the distance of the shadow thrower from and its relative position to the radiator. A stick placed parallel to a Moore tube throws a sharp shadow, but if this stick had been placed at right angles there would have been hardly any shadow. The stick placed under a street lamp with a high candle power fixed to a low post in such a manner that the light falls under an angle of, say, 30 degrees upon the stick causes a black shadow, whereas at a considerable distance the shadow is less distinguishable. In this case the next lamp takes some part in the illumination, causing it to be more diffused. Even in a room with a fairly uniform illumination, we may find that, from a physiological standpoint, the illumination is satisfactory only in a few places, as can be easily tested by producing shadows.

Where a number of lamps cast a shadow of a rod, in different directions, the illumination, even in the shadow area, is usually sufficient; but near a corner of the room this might not be the case, since here this illumination may be chiefly due to one lamp, and the shadow thrown, in consequence, very dark.

It will be obvious from these remarks that the quality of an illumination must be judged almost entirely by the ability with which we recognise fine details; the illumination should, in consequence, be neither too little nor too much diffused. As we have to deal with two sciences, it follows that the judgment cannot be easily formed. Testing the illumination with photometers may satisfy the physical science, but, it gives no indication as regards the physiological quality. An attempt has been made by Dr. Konrad Norden (see *E.T.Z.*, 1911, p. 607) to bring the physiological quality of an illumination within the range of mathematics.

He expresses diffusion as the extent to which shadows are illuminated. The more we illuminate the shadows cast by a

Fig. 1.—A view of the Common Room in the Hiddingh Hall, S. African College, Cape Town.

Fig. 2.—The Assembly Hall, S. African College, Cape Town.

single radiator by means of other illuminants, the more perfect is the resulting diffusion. When the illumination is by a single point source, the diffusion D is nil, and when no shadows are cast it is perfect and has the value unity. All other cases lie between these two values. This may be expressed as follows :—

$$I \geqq D \geqq 0$$

Although it is possible to express the diffusion, or rather the "shadow-power" ($Sp = I - D$) by some formulæ for very simple cases, as has been done by Dr. Norden, its practical value will be small until further experiments are carried out which tell us exactly what diffusion is needed for the recognition of fine details, and before instruments are devised enabling us to determine the shadow power of the installation and to express it physiologically. It appears to the author that the Holophane lumeter would probably be suitable for the purpose.

Fig. 3.—The Library, Hiddingh Hall, S. African College, Cape Town.

Fig. 4.—Physiological Lecture Room, S. African College, Cape Town.

The Lighting of the New Buildings of the South African College.

The remarks made so far will give some indication as to the basis on which the lighting of the New South African College Buildings has been carried out.

The Hiddingh Hall.

The photograph of the Students' Common Room has already been given in Fig. 1. The actual number of lamps installed in this room is ten, of the 50-watt-tungsten type, with a mean spherical intensity of 35 candles. The average illumination is about 2·6 candle-feet, whereas, according to curves published previously by the author,* it should have been about 2·7 candle-feet, which shows a very fair agreement. The degree of uniformity is very high, the ratio maximum value over minimum value being 1·2.

Fig. 2 represents the Assembly Hall. The illumination consists of seven chandeliers of five lamps each, all of twelve brackets with two lamps each. The ceiling is white and the walls are teak panelled up to a height of ten or twelve feet. This panelling was not contemplated originally, and as a result the brackets on the walls are fixed near the top of the teak panelling. A better result would have been obtained if the brackets had been placed above the windows on the white wall. As it is, the bright lamps in front of the teak panelling

* See the author's text-book.

FIG. 5.—The Dissecting Room in the New Medical School, S. African College, Cape Town.

FIG. 6.—Experimental Laboratory of the Professor of Physiology, S. African College, Cape Town.

provides a fair amount of contrast. The illumination is, however, fairly satisfactory without the wall brackets, although the diffusion is not nearly so great. This one can easily notice by studying the faces of people in the hall. With all the lamps on, the wrinkles in people's faces are not nearly so noticeable as they are with the wall brackets switched off. With all the lamps on the illumination varies from $2\frac{1}{2}$ to $3\frac{1}{2}$ candle-feet.

In Fig. 3 is given a photograph of the Library. The room is divided by means of bookshelves into twelve alcoves, each about 11 ft. 6 in. by 8 ft. 6 in., leaving a free central space of 10 ft. 9 in. The height of the room is 15 ft. The general illumination consists of six tungsten lamps, giving about 35 M.S.C.P., fixed close to the ceiling, with conical opal shades. The illumination of each alcove is brought to the required amount by the addition of similar lamps fixed to rising and falling pendants. The illumination is perfectly satisfactory when the lamps are about level with the top of the bookshelves. There is also sufficient light for reading the names of the titles of books even at the bottom of the shelves.

The New Medical School.

Fig. 5 shows a photograph of the new Dissecting Room. In a room of this nature, a very high illumination is required on the tables, and, in consultation with Dr. Thomson, it was decided to place a rising and falling pendant with Holophane reflectors upon each table. Originally, two lamps were contemplated for each table, but the number was reduced, on account of cost. As it is the lighting is quite satisfactory in every respect. The number of lamps is sufficient to give a very uniform general illumination, and with Holophane reflectors above the lamps, the light is sufficiently concentrated downwards to give a high illumination where it is wanted. The reflectors are deep enough to prevent any glare, especially as the surroundings are practically white.

Fig. 4 represents the Physiological Lecture Room, also directly lighted with lamps close to the ceiling, but with special reflectors for the blackboard lamps. Fig. 6 shows the Experimental Laboratory of the Professor of Physiology. Here the lamps are again close to the ceiling, well distributed, giving a very pleasing appearance to the interior.

To those who went over the building it might appear that the light was somewhat too plentiful. It must, however, be remembered that a medical building should be correctly illuminated in every respect, and the photographs indicate sufficiently that these results have been achieved, not only from a physical but also from a physiological standpoint. Glare is entirely avoided in all the rooms, and the light is well diffused where a great diffusion is wanted, and yet, everywhere, the finest details are recognisable.

Illuminating Engineering Society

(Founded in London, 1909.)

CHANGES OF ADDRESS:—

Chandler, S. B., Sales Department, South Suburban Gas Co., Lower Sydenham.

Wingate, F. M., Dispensing Optician, 30, Wigmore Street, London, W.

The following name was inadvertently omitted from the published list in our last number:—

C.M. Moore, D. Macfarlane, General Electric Co., Harrison (N.J.), U.S.A.

SOME NOTES ON THE LIGHTING OF A SMALL LECTURE THEATRE.

By C. E. Greenslade.

(*Head of the Electrical Department at the Crawford Technical Institute, Cork.*)

The writer was much interested in the Interim Report of the Joint Committee on School Lighting published in this Journal last month. The lighting of the Electrical Engineering lecture theatre at the Crawford Technical Institute in Cork has been the subject of many experiments, and a few particulars about the lighting of this room may be of service. Most of the conclusions reached in these investigations are very similar to those of the Committee.

Fig. 1 shows a plan and elevation of the room. The area occupied by the students' desks is about 350 sq. ft.; the corresponding area for the lecturer's portion of the room 250 sq. ft. The height of the room is 13¼ ft. at the front and 10½ ft. at the back.

The general illumination is provided by three 40-watt tungsten lamps in Holophane I.60 reflectors. The consumption for this area of the room is only 0·3 watts per square foot. As will be seen from Fig. 1 the illumination for the benches is very even, being slightly under 2 foot-candles.

The lamps are placed high up on the ceiling and out of the range of vision of the students. The big girder on the ceiling (visible in Fig. 2), prevents the lecturer seeing the lights, but it has the drawback of making part of the ceiling rather dark. The surface brightness of the ceiling is at present only about ¼ foot-candle and that of the walls ½ foot-candle. The writer has come to the conclusion that in order that a room may appear to be cheerfully lighted, and that there may appear nothing oppressive in the appearance of the ceiling, the brightness of the ceiling should be not less than twice that of the walls. Some rearrangement of the lights will be attempted with a view to getting nearer this ratio.

The arrangements for the lecture table and blackboard will be understood from Figs. 2 and 3. The table is lighted by two 60-watt tungsten lamps in Holophane Benjamin Steel reflectors, giving an illumination on the table of from 2–4 foot-candles. Opaque reflectors which completely screen the source of light from the eyes of the students

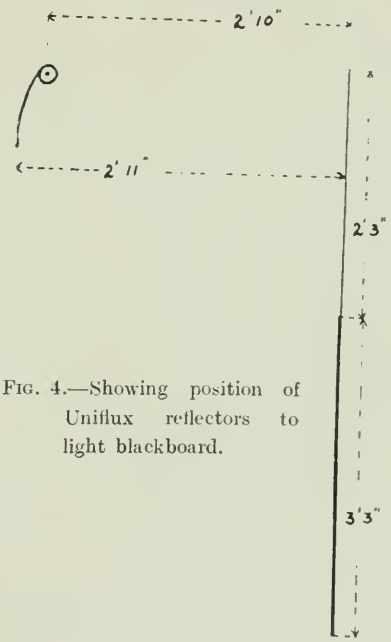


Fig. 4.—Showing position of Uniflux reflectors to light blackboard.

are most suitable for the illumination of the demonstration bench, as they can be hung at a fairly low level.

An interesting feature in the design of the bench is the raised shelf at the back which covers the wires carrying the current to the bench for experimental purposes. The bench top is painted a lead grey to show up coloured wires and apparatus clearly.

The lighting of the blackboard is carried out by two one-foot length Holophane Uniflux reflectors arranged as shown in Fig. 4. The blackboard is roughly $12\frac{1}{4}$ by $3\frac{1}{2}$ sq. ft. The numbers chalked on the board and shown in Fig. 3 indicate the distribution of the illumination, which averages about 4 foot-candles.

The Uniflux reflector occupies an almost vertical position somewhat different from what theoretical considerations would suggest to be desirable; this is due to the fact that the lower portion of the blackboard receives a certain amount of light from the lamps for the lecture bench.

The illumination for the blackboard is very uniform considering that it is produced by only two units. The illumination provided, 4 foot-candles, easily enables diagrams in coloured chalk to be seen. The experiments carried out in this room suggest that it is not a good plan to increase the illumination of the average blackboard much beyond this figure. It is rather curious that in recommendations on illumination, stress is always laid on the necessity for a certain minimum illumination, but little is said regarding the desirable *maximum*. It was found that when the blackboard illumination was increased much beyond the figure indicated, acuteness of vision is to some extent interfered with. It is possible that this is due partly to the amount of light reflected from particles of chalk on the board, but it may also be that at these higher illuminations there is a certain amount of "irradiation" (*i.e.*, physiological spreading of the images of the white figures).

A rough rule that might perhaps be suggested is that the surface brightness of the blackboard should be about the same as that of the desks in the lecture theatre, and ought not to exceed 0·3 foot-candle. In this case the illumination on the blackboard will be considerably higher than that on the desks.

All the figures given for illumination are those obtained at the end of the session without special cleaning of any kind

There are several other points in blackboard lighting which have to be considered and which seem to be met by the arrangements in this theatre. It is, of course, essential that the lamps should be completely screened from the eyes of students by an opaque reflector. This must be so placed that the lecturer, when turning away from the blackboard, is not dazzled by seeing naked filaments; and there must also be no inconvenient shadows of the head cast on the board. Another point to be noted is that the rays of light should not strike the surface of the blackboard at a very oblique angle. Tubular reflectors have sometimes been mounted close to the top of the blackboard so that the light strikes the surface very obliquely. In these circumstances all the small particles of chalk left on the blackboard are lighted up and the writing on the board seems to be seen through a sort of luminous haze. High local lighting of this kind may actually be a drawback, making it more difficult to read the figures than no local lighting at all.

Attention may next be drawn to the screen for lantern diagrams, placed on the right of the blackboard (see Fig. 2). This is about 3 feet square. The projection lantern is placed on the lecture table and throws an exceedingly bright image on this screen. When no slide is in use the illumination is about 22 foot-candles; whereas with an ordinary lantern arrangement and a screen about 10 ft. square not more than 1 foot-candle is usually obtained. The advantage of this high illumination is that pictures can be thrown upon the screen and seen without difficulty even while the general lighting of the room is kept on. It should be mentioned that no student sits farther than 24 feet from this screen. It is hardly possible to show complicated tables, but the arrangement answers excellently for plans and illustrations not having a great deal of fine detail. As a matter of fact it may be questioned whether it is worth while to show complicated tables and diagrams as lantern slides, for the lecturer cannot keep them on long enough for his audience to examine them properly. Experience at the Crawford Institute

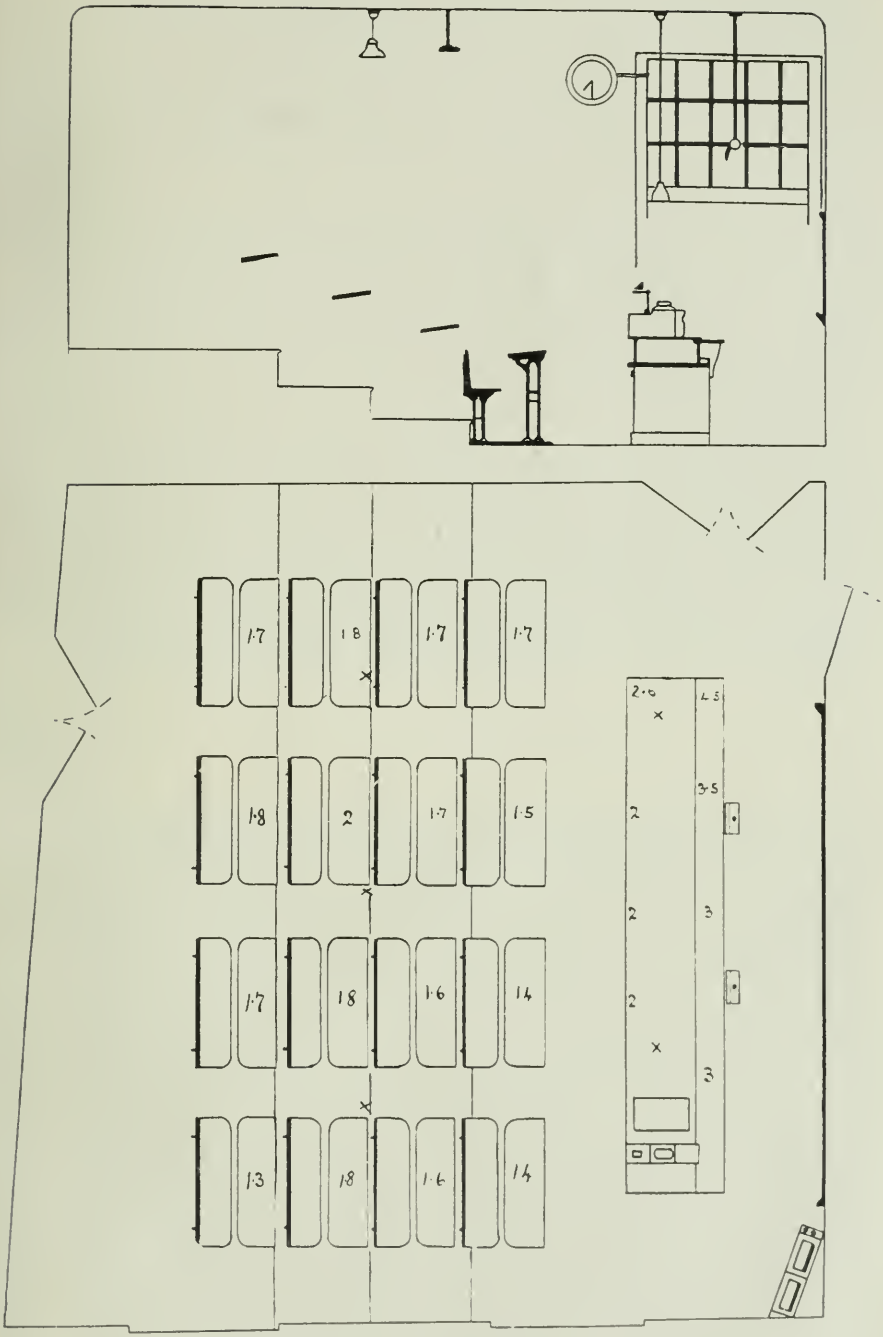


FIG. 1.—Plan and Elevation of Lecture Theatre, showing the arrangement of the light. The numbers indicate the illumination in foot-candles provided on the desks and demonstration table. Area 25 ft. × 24 ft.

has shown that, in the case of tables summarising data of permanent value, it is a better plan to make up a diagram which can be hung up in the lecture theatre continuously; an opportunity is thus given for the matter presented to "sink into" the minds of students.

The only other point that deserves mention is the local illumination of the electrical measuring instruments. These will be seen on the right in Fig. 2. This is carried out by means of Tubolite lamps and reflectors, the lamps being, of course, completely concealed from view and controlled by a sunk Twinob switch in the bench top.

Experiments on lighting are being made in other parts of the Institute, and it is possible that on a future occasion the writer may be able to give some particulars of these. In one room a rather interesting expedient has been adopted, namely, the use of Holophane reflectors (of the type commonly employed with gas units) with Excello arc lamps hung above the ceiling windows. The illumination on the working plane is materially improved thereby together with complete absence of glare. An illumination of about 6 foot-candles (indirect lighting) is provided for the drawing offices. While 5 foot-candles might be taken as a minimum for ordinary work, it is essential to exceed this value and to use *direct* lighting in the case of fine tracing.

In conclusion it may be mentioned that the writer proposes to extend the course on lighting at the Institute, and at the present moment is considering the planning of special experiments on illumination. In the past there has been a tendency at Institutions to bore students needlessly by tedious calculations and old-fashioned photometric apparatus; we should now try to reduce labour of this kind to a minimum, so as to enable the student to make practical experiments on illumination at an early stage.

SOME NOTES ON REFLECTORS AND GLOBES.

By Arthur Blok, B.Sc., A.M.I.E.E.

It will be recalled that at a meeting of the Illuminating Engineering Society, held in the early part of the present year, a paper dealing with some general problems in the design of globes and reflectors was read.* The subject is one of great importance, and it occurred to the author that some additional information about a few typical fittings commonly met with in practice would be welcome.

The results were in all cases obtained by means of a form of three-mirror rotator developed by the writer for the purpose of rapidly obtaining polar curves of intensity.

In this device (Fig. 1) three inclined mirrors, M^1, M^2, M^3, are carried in a frame, F, which is arranged to turn about a horizontal axis passing through the tested lamp, L, and to direct the light on to the photometer screen, P. With this arrangement, the lamp under test remains immovable and the rays always arrive upon the photometer disc normal to its surface, whatever be the angular position of the mirror frame with regard to the lamp. The photometer box was fixed, and balance was obtained by means of a small movable electric standard lamp, E, supplied from a 4-volt accumulator.

A special object of the series of tests from which most of the results are drawn

* Illum. Eng., Lond., March, 1913.

FIG. 2.—A view of the blackboard, illuminated by Uniflux Reflectors. The numbers chalked on the board indicate the illumination provided.

FIG. 3.—A view of the Lecture Theatre from the back showing the method of illuminating the bench and blackboard.

was to ascertain whether it is possible when working on commercial gas or electric supply systems to obtain reliable polar curves without having to employ regulating devices of such a nature as to be suitable only for laboratory conditions of refinement. In some of the curves the observed points are shown by way of example. From the uniformity of the results it would appear that with the series of tests. With the electric lamps a plain sliding rheostat was used in series with an open scale ammeter, the meter and resistance being placed on the bench immediately below the photometer. By glancing at the ammeter immediately before each balance and adjusting the resistance, if necessary, the observer could easily ensure a very constant current value in spite of the

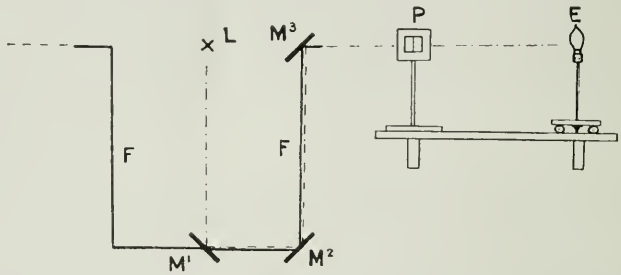


Fig. 1.—Arrangements for Photometric Measurements by means of Three-mirror Rotator.

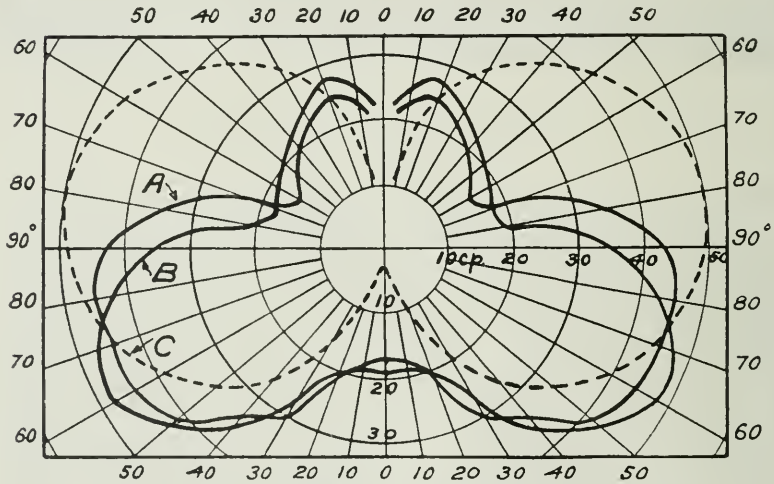


Fig. 2.—Polar Curves of Upright Mantle with Opaline Reflectors shown in Fig. 3. (A=with reflector A, B=with reflector B, C=without reflector.)

quite simple means for regulating the illuminant, results of very considerable value may be obtained easily and without the need of very expert manipulation or knowledge. For the gas tests a simple Borrodaile governor was used, and it was found that the pressure at the burner remained constant within 0·1 to 0·15 in. of water although the main pressure varied from 3·5 to 6·5 in. during ordinary small voltage variations on the supply mains. A Leeson star disc with the usual V-mirrors was used in the photometer box, and no appreciable trouble arose through colour differences. The distance traversed by the ray from the source *via* the mirrors to the disc was in all cases 235 cms.—*i.e.*, the fittings were tested at an effective radius of 7 ft. 8 in. It was concluded, after investigation,

that with ordinary symmetrical globes or reflectors it is sufficient for practical purposes to test over one semicircle only around the lamp; that is to say, the flux distributions are substantially the same in all vertical hemispheres described about the source. With asymmetric fittings, such as that shown in Fig. 4,

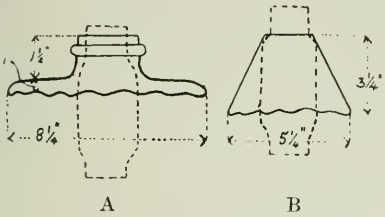


Fig. 3.—Opaline "Jena" Reflectors.

readings must, of course, be taken around the complete circle. Measurements were made at every ten degrees as a rule, and at closer angular intervals when the curve was changing its shape rapidly.

In connexion with the curves, it must be pointed out that the illuminants, both gas and electric, were underrun in some cases. Thus, the mantles were usually run at pressures between 1·5 and 2 in., the object being to investigate the effects of the globes, &c., on the *shape* of the intensity curves rather than to determine the *output* of the fixture as a whole in terms of total lumens per cubic foot of gas per hour in ideal burning conditions.

Fig. 2 shows the results given by an upright gas mantle with two opaline

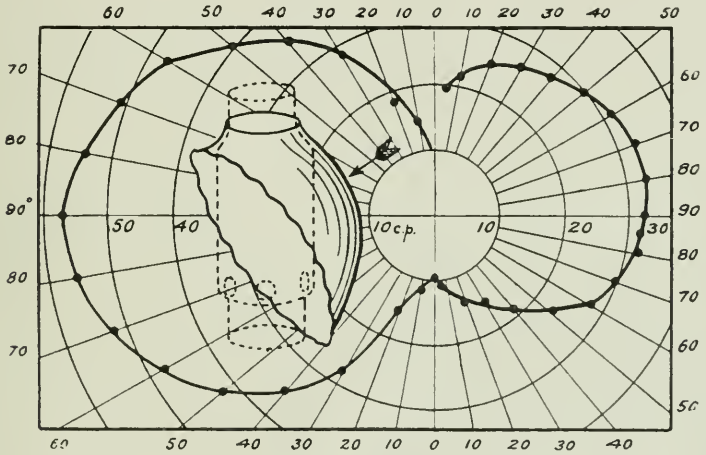


Fig. 4.—Polar Curve of Upright Mantle with "Parabolic" Opaline Reflector.

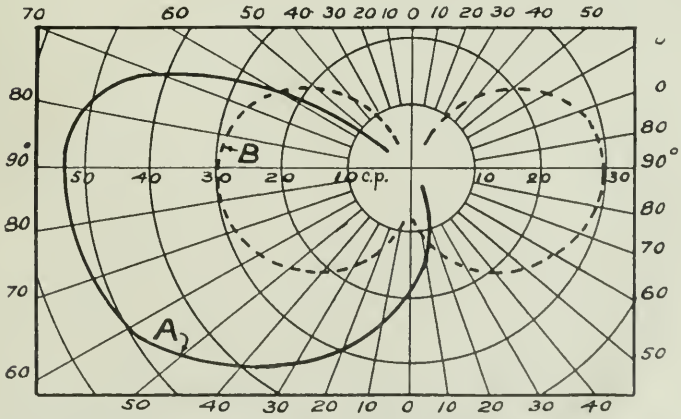


Fig. 5.—Polar Curve of Tungsten Lamp with Aluminium-faced Steel "Parabolic" Reflector. (A = Lamp with reflector. B = Bare lamp.)

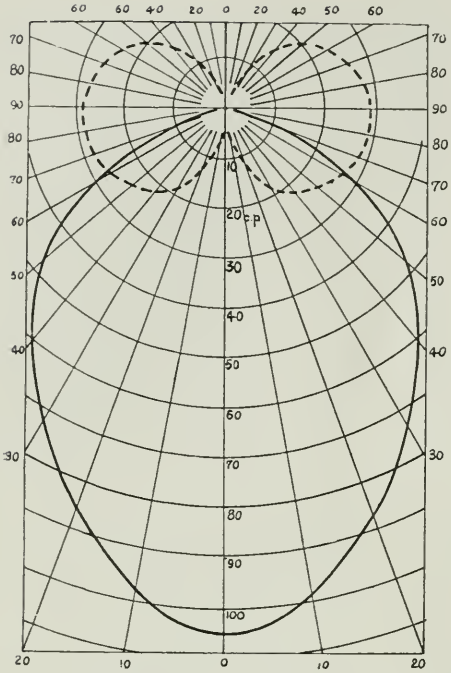


Fig. 6.—Polar Curve of Tungsten Lamp with Mirror Reflector.

"Jena" reflectors and a $6\frac{1}{4}$ in. "Normal" clear glass chimney, as shown in Fig. 3. In Fig. 2 the dotted curve, C, is that of the mantle and chimney alone. These reflectors are of very thin material and allow a fair proportion of light to pass through them into the upper hemisphere. The upwardly-pointing lobes of the curves are due in part to transmitted light and in part to light coming directly from the upper regions of the mantle through the clear chimney. The performance of these reflectors is as follows :—

	Bare Mantle	Reflector A	Reflector B
	c.p.	c.p.	c.p.
I_0	38·4	31·8	31·4
I_u	34·6	39·7	40·8
I_l	42·1	23·9	22·0
Ratio I_u/I_l	1·22	0·60	0·54
Loss % ..	—	17·2	18·25

(I_0 = mean spherical c.p., I_u and I_l = mean upper and lower hemispherical c.p. respectively.)

It is somewhat surprising that the cone does not give a higher loss in comparison with the shallow form. It was noted, however, that the cone was somewhat more translucent than the other one and this, no doubt, accounts to some extent for its good performance.

An asymmetric opaline "Jena" reflector for an upright mantle, together with its polar curve, is outlined in Fig. 4. The vertical height of the reflector, when in position on the chimney, is 6 in.; the elliptical opening has axes 6 in. and 5 in. long, and makes an angle of about sixty degrees with the horizontal plane. The relatively large lobe in the right-hand upper quadrant is due to the fact that the maximum luminous surface on the closed side of the reflector is seen from the region indicated by the arrow. The polar curve of a reflector of similar character for electric lamps is shown in Fig. 5. This reflector has a practically circular opening inclined at forty-five degrees to the axis of the lamp and is made of steel with a frosted aluminium inner surface. The light of the right-hand hemisphere is thrown back so as nearly to double the

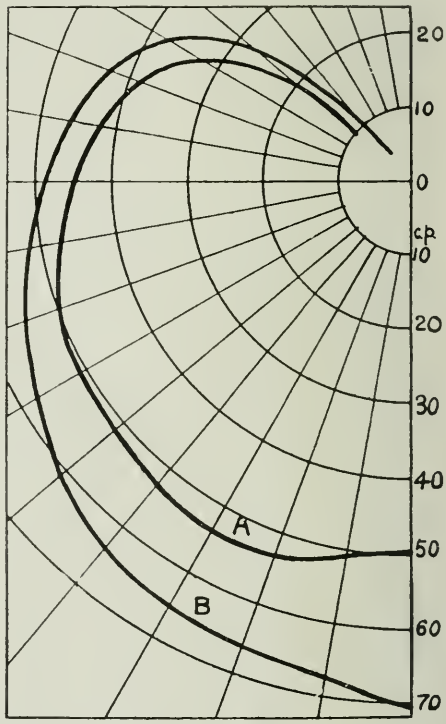


Fig. 8.—Increase in Candle-power of Inverted Mantle by Employment of Globe.
(A = Bare mantle. B = Mantle with clear glass spherical globe.)

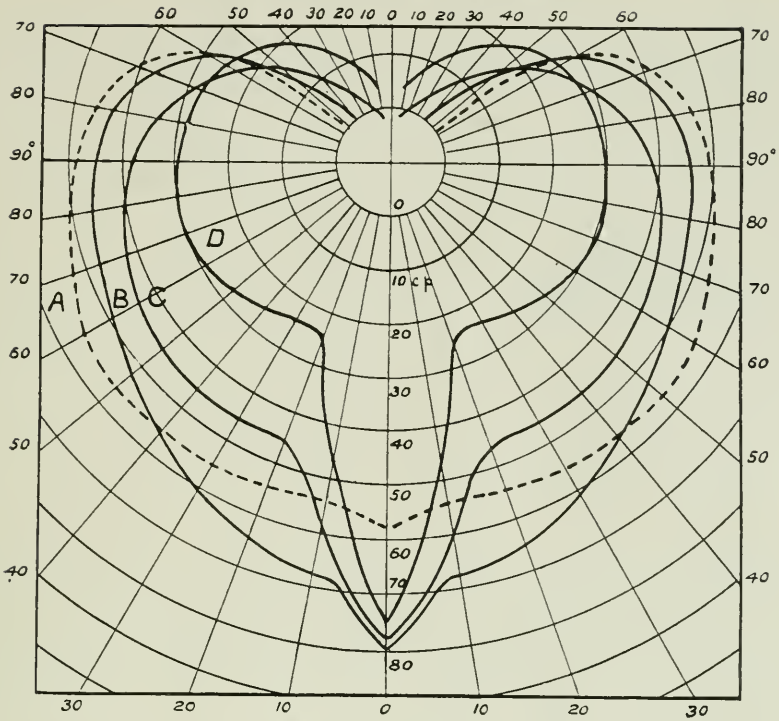


Fig. 7.—Polar Curves of Inverted Mantle with Spherical Globes of Increasing Obscurity.

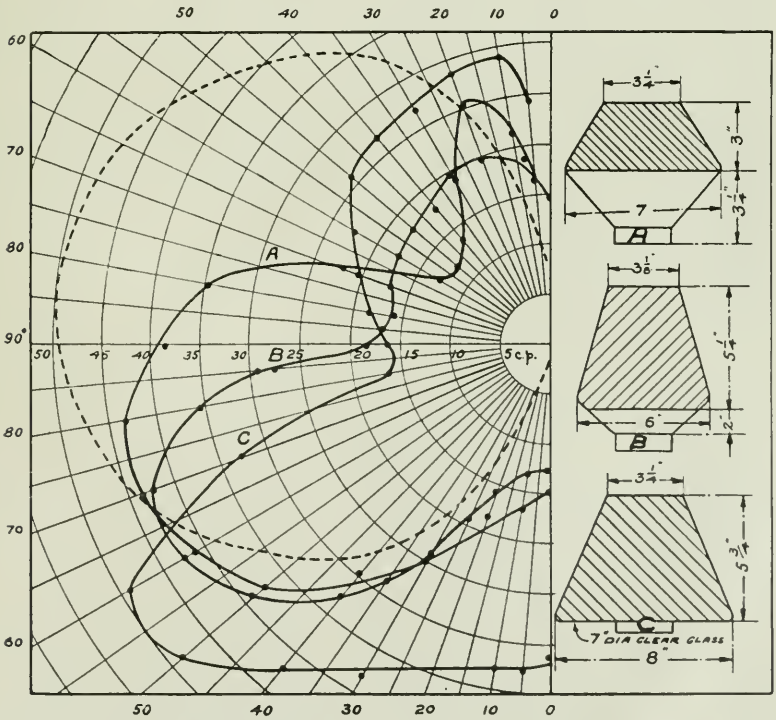


Fig. 9.—Polar Curves of Upright Mantle with Three Globes with Opal Flashing.

horizontal intensity on the left and give a greatly augmented flux in downward directions on that side.

Silvered glass, although good as a reflecting medium, has the disadvantage of giving streaky effects, in addition to which it is apt to tarnish unless of very

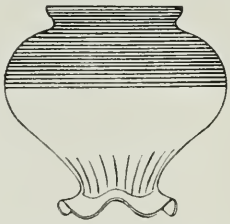


Fig. 10.—Opal and Clear Glass Globe for use with Incandescent Mantle.

good manufacture. The streaking is usually overcome by ribbing or corrugating the surface. The polar curve of such a reflector when used with a bare metal filament lamp is shown in Fig. 6, and brings out the intensely focusing character which is usually associated with silvered glass and similar reflectors. It should be borne in mind that the shape of the polar curve of a focusing device depends, to some extent, upon the distance at which it is tested, since some of the rays may be sent out as a parallel beam and some by diffuse reflection.

Turning to globes or shades, the ideal material for making these is the one which becomes luminous with a maximum of uniformity and with a minimum absorption of light. A thick opal globe is good in so far as it becomes uniformly bright all over and has a low intrinsic brilliancy, but on the other hand the absorption loss is great, and in this respect it is a bad globe.

In Fig. 7 are shown the results of using with an inverted mantle three spherical globes all of the same size, but having different diffusive qualities. The distribution of the bare mantle is shown by the dotted curve, A. Globe B has a fine floral pattern, the lines being about 0·5 mm. wide and cut rather deeply into a clear glass body. Globe C is ground all

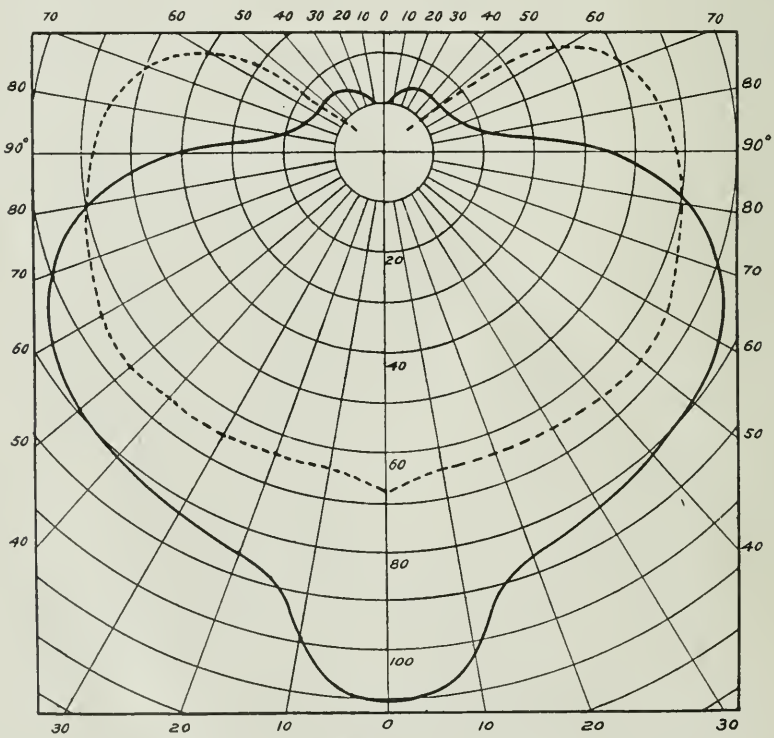


Fig. 11.—Polar Curve of Inverted Mantle with Opal and Clear "Optic" Globe.

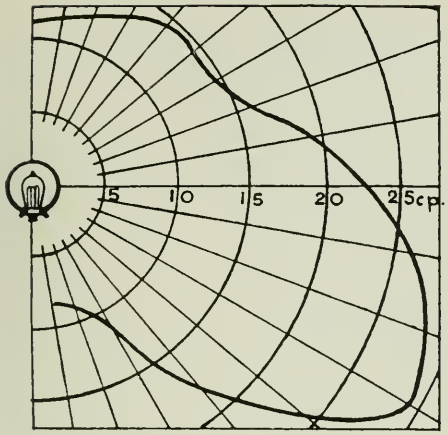


FIG. 12.—Polar Curve of Tungsten Lamp in Prismatic Glass Sphere for upright use.

over somewhat heavily, and Globe D is of thick white opal glass. Excluding the downwardly-pointing extensions, the results show that the original curve is smoothed out so as to approach a circular form as the diffusive obstruction to the light becomes greater. As the diffusing medium becomes more opaque, more internal reflection occurs in the globe and a greater proportion of light is thrown upwards. Simultaneously the loss by absorption becomes greater, and the surface of the globe becomes more uniform in brightness. The performance of these is as follows :—

	Bare.	Globe B.	Globe C.	Globe D.
	c.p.	c.p.	c.p.	c.p.
I_0	47·1	46·8	41·7	35·1
I_u	63·7	61·5	53·2	38·5
I_1	30·6	32·0	30·2	31·8
Ratio I_0/I_1	0·48	0·52	0·57	0·83
Loss %	—	0·8	11·5	25·4

The light below these globes is due in part to the tip of the mantle which could be seen through a draught hole below the burner, and in part to the luminous effect of the globe itself, the result being that the curve is extended downwards in the form of an increasingly sharp tooth. This extension, being on the vertical axis, adds very little to the mean spherical intensity, but it may be of value in circumstances demanding a localised bright patch. The percentage losses in the above table are apparently too low for the given materials—obviously the patterned globe must have absorbed more than 0·8 per cent. of the light. The explanation is found in the higher temperature around the mantle produced by the screening effect of the globes as compared with the temperature when the mantle is burning bare. The effect is shown in Fig. 8. Curve A is from a bare mantle in practically the same conditions as that giving the curve A in Fig. 7, but when the mantle was enclosed by a spherical clear glass globe the curve was altered to the form shown at B. Although

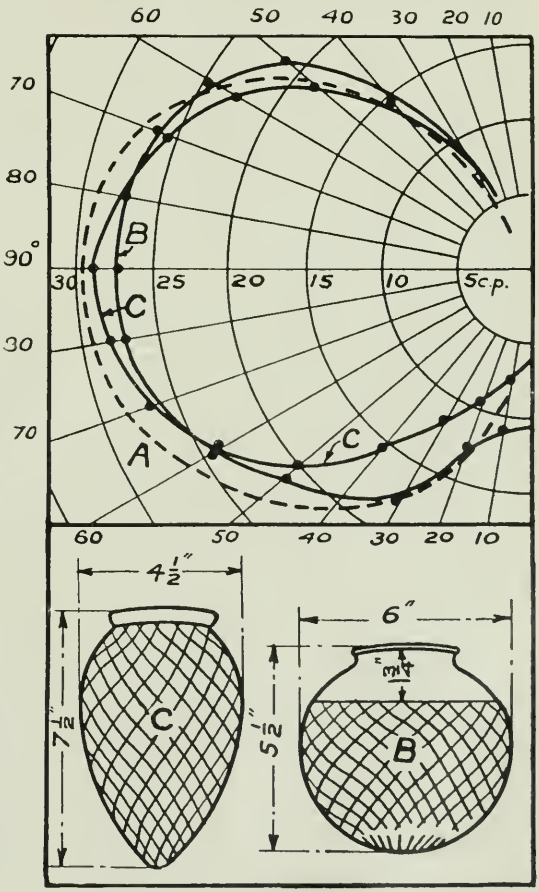


FIG. 13.—Polar Curves of Tungsten Lamp with Cut Glass Sphere (B) and Clear Moulded Stalactite (C).

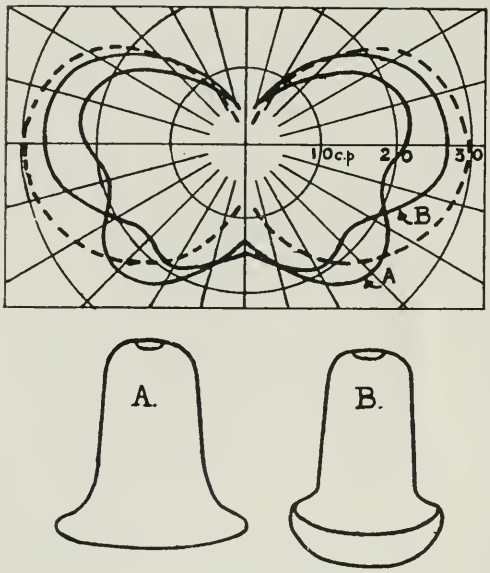


Fig. 14.—Polar Curves of Tungsten Lamp with Bell-shaped Globes of Cracked Glass Iced on Outer Surface.

the actual absorption in the glass was known to be about 6 per cent., the mean spherical candle-power has an apparent increment of 16·4 per cent.

Fig. 9 shows the curve of a bare upright mantle and the modifications produced by three flashed opal and flint globes having opal zones of increasing depth, as shown at the side of the Figure. From the lower parts of the curves it is evident that bringing down the opal zone has the effect of increasing the downward reflection. The lobes in the upper hemisphere are due to at least three components, which differ in magnitude in all three specimens. They are: (1) light coming directly from the mantle through the hole at the top of the globe, (2) light reflected through the hole from the inner surfaces of the globe, and (3) light transmitted upwards through the opal material. These curves show the following results :—

	Bare	Globe A.	Globe B.	Globe C.
	c.p.	c.p.	c.p.	c.p.
I_0	38·46	28·7	25·1	28·8
I_u	34·6	35·5	32·6	34·7
I_1	42·4	21·9	17·6	22·9
Ratio I_u/I_1 .	1·22	0·62	0·54	0·66
Loss % .	—	25·4	34·8	25·1

A globe for use with inverted mantles and having a similar tendency to those just dealt with, viz., downward reflection, is the familiar opal and clear flint "optic" pattern shown in Fig. 10. In properly designed specimens, the opal cap extends down at least far enough to hide the mantle when it is viewed horizontally. The ribs on the lower portion are a valuable feature in that they break up the elevation of the mantle when it is viewed from the lower hemisphere and thus reduce the intrinsic brightness of the source. The curve for this is shown in full line in Fig. 11, and it is seen that almost the whole of the light from the upper hemisphere is turned downwards, giving a well spread and intense light below the fitting. In the sample tested, the candle-power vertically downwards was increased by 58 per cent. and the apparent loss of light was only 4 per cent.

The curve of a Holophane sphere for upright use with electric lamps (Fig. 12) shows how well it fulfils the object of directing the light downwards. This curve should be compared with that of an ordinary cut-glass sphere, shown at B in Fig. 13. The cut sphere was of substantially the same size as the prismatic one referred to above, but by comparison with the curve A of the bare lamp it is seen to have practically no redirective influence. In fact, ordinary cut glass has few merits apart from appearances, and the same may be said for moulded glass. Curve C, Fig. 13, is given by a moulded clear glass stalactite (also shown), and here, again, practically no redirection of light occurs.

Fig. 14 shows the curves for a pair of

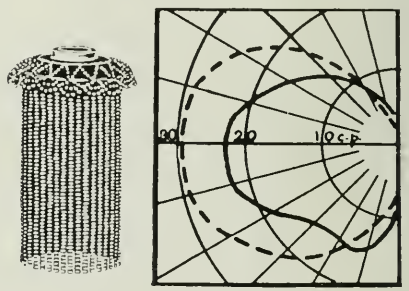


Fig. 15.—Polar Curve of Tungsten Lamp and Bead Fringe.

electric lamp globes having the shapes indicated to scale by the sketches. These are both made of crackled colourless glass with an iced surface. The effect of the inturned lip of the globe B is to redirect much of the light upwards, giving an augmented horizontal and upward intensity in comparison with the open bell A. A bead fringe for an electric lamp is shown in Fig. 15, together with its polar curve. This device is made of blue-white opalescent glass beads, and is evidently wasteful in light, whatever may be its merits as an article of ornament.

FACTORY LIGHTING.

Some Notes on the Annual Report of the Chief Inspector of Factories and Workshops for the Year 1912.

"Lighting in the past has not perhaps received all the attention it deserved, but is rapidly becoming a more prominent question." This sentence summarises the view of the Factory Department on matters of illumination. It is hoped that the results of the Departmental Committee on Industrial Illumination now sitting will be very valuable in suggesting improvements, but meantime investigations are constantly being made by the inspectors and useful experience is being obtained.

Lighting of Printing Works, Docks, Potteries, &c.

The Report makes reference to quite a number of instances of poor lighting causing accidents. Mr. May (Dublin) mentions that he nearly fell into a pit in a passage at a gas works owing to the defective illumination. Mr. Edwards (Cardiff) mentions a case of a coal-trimmer walking along the decks after dark and falling through an open hatchway. A fortnight later a second accident of the same kind occurred and the coroner adjourned the inquest for a couple of hours so that the jury and he could satisfy themselves as to the causes of the mishap. Later on in the year yet a third accident of this kind occurred. It is evident that the lighting of a ship at the docks is a vital matter, and it may be noted that in one of these cases "proceedings were taken in respect of the unfenced hatchway and want of lighting."

Substantially the same remarks were made by Mr. Wilson of Glasgow. He points out that a vast amount of work must necessarily be done in the interiors of ships lying at the dock for loading or repairs entirely by artificial light. Very often the existing light is insufficient, and the wiring in these circumstances is also apt to be below the proper standard. Among other industries in which bad illumination is prevalent were mentioned potteries and locomotive works. Lady inspectors called attention to the inadequate light in a bookbinding factory, and in basement workrooms where the eyestrain is apt to be exceptionally severe. The lighting of weaving rooms (which, it will be remembered, were the subject of a special investigation by Mr. D. R. Wilson last year) has also been receiving attention. It is interesting to note that in an Appendix containing the agreement reached at a recent cotton-weaving conference it was specifically laid down that "passages and staircases shall be effectively lighted either by natural or artificial means."

Lighting of Iron Foundries.

Mr. D. R. Wilson, whose valuable work published in the report for 1911 we have frequently had occasion to mention, again contributes a special report on the artificial lighting of iron foundries. Here insufficient light is particularly objectionable owing to the danger of accidents being caused by stumbling through the passage from one part of the foundry to another, and especially when handling molten metal. The chief requirement in this industry is therefore sufficient general rather than local illumination.

The chief characteristics of an iron foundry, from the point of view of lighting, are stated by Mr. Wilson to be as follows :—

(1) The whole of the floor space is covered with very dull and dark material. Measurements of the diffused reflecting power of this surface indicate that only about 2 to 3 per cent. of the incident light is reflected.

(2) The material covering the floor is of uniform colour, and there is almost complete lack of contrast throughout the room. There is, therefore, no surface to serve as a contrasting background for obstacles, which are often difficult to distinguish.

(3) The processes involve the production of much dust, and at certain stages of the work dense smoke is evolved.

(4) Shadows are said to be specially undesirable, probably on account of the further reduction of the illumination.

(5) Glare is liable to result from the molten metal (and sometimes from badly shaded light sources placed too low), with the consequence that the eye is temporarily dazzled, and risk of stumbling is increased.

The constant blackening of the surroundings and the presence of smoke in the room tend to reduce the effect of illumination considerably and frequent whitewashing of the walls is to be desired. Dense shadows must also be avoided. It is therefore recommended that a number of sources of moderate candle-power placed fairly high up in the room should be preferred to a few units of great concentrated brilliancy.

Perhaps the most interesting feature of Mr. Wilson's Report is the concluding table in which the measurements made in various factories are tabulated in a very complete fashion. In some of these especially those lighted by gas flat-flame burners, the illumination was exceedingly poor, and modern up-to-date methods of gas lighting should be substituted.

Tentative Standard of General Illumination.

Taking the illumination in the horizontal plane 1 ft. above the floor, Mr. Wilson classifies the factories visited as follows :—

Well lighted iron foundries, illumination does not fall below	0·5 f.c.
Fairly ,, ,, ,, ,, ,, ,, ,, ,,	0·3—0·4 ,,
Moderately ,, ,, ,, ,, ,, ,, ,,	0·2—0·3 ,,
Poorly ,, ,, ,, ,, ,, ,, ,, ,,	0·1—0·2 ,,
Badly ,, ,, ,, ,, ,, ,, ,, ,,	0·2 ,,

It would seem, therefore, that the lighting might be deemed insufficient if the illumination falls below one-third of a foot-candle. It is interesting to note that this figure is very close to that suggested for the lighting of main railway platforms at a meeting of the Illuminating Engineering Society last year. This would seem to be a figure that would apply to many yards and spaces where fairly large objects are handled and a fair general illumination is required on the ground of convenience and safety.

THE NEED FOR GOOD ILLUMINATION IN TRADES AFFECTING THE EYES.

Some Notes on an Interesting Report presented by the Committee on Industrial Pathology, appointed by the Royal Society of Arts in 1855.

Our attention has been drawn to a most interesting report presented by a Committee on Industrial Pathology appointed by the Royal Society of Arts so far back as 1855—at a time when interior gas lighting was, comparatively speaking, in its infancy, and most people were still satisfied with oil lamps or candles.

The report deals with the Preservation of Eyesight. It is a striking instance of the characteristic enterprise of the Royal Society of Arts. Evidently even in these early days many modern problems in illumination had already made themselves felt. For example, special reference is made to the prejudicial effect of glare. How much more important must this matter be in our present age of brilliant illuminants.

Among trades and industries that are admittedly responsible for defective eyesight, Mr. Dixon, a surgeon to the Royal Pathological Hospital, mentioned tailoring, needlework, dressmaking, clerical work, boot and shoe making, and engraving. Workers in these trades suffer severely through insufficient and unsteady light. Among weavers also failure of sight from over use of the eyes was found to be common owing to insufficient lighting of their work rooms in the evening.

Among those who suffer from *excess of light* in the form of glare from furnaces, &c., he mentions glass blowers, smelters, and assayers. There are other operators (metal burners, mill stone drawers, smiths, and masons) who are exposed to the risk of mechanical injury from particles of grit or metal. In these trades the use of goggles equipped with wire gauze is recommended.

Reference was also made to the strain of printing work on the eyes. This had already led compositors to devise shades which they often made for themselves out of cardboard and fixed on the benches. Several of those who gave evidence shared the impression that red rays are apt to be trying to the eyes, and blue glass goggles are recommended as a means of mitigating this effect. It is also suggested that needlewomen would find it advantageous to change the colour of the work as frequently as possible. Constant work on one colour, it is suggested, is apt to be trying to the eyes, and the best colour for the surroundings is green.

Stress was laid on the effect of heat from the illuminant. Charcoal fires were considered pernicious in this respect. Spectacles which were found to be beneficial by daylight were sometimes found inconvenient by gaslight owing to the glass being heated by the near proximity of the light. (It must be remembered that this refers to the early days of flat flame burners.)

The illuminated sign was unknown in those days, but the custom of decorating shop fronts with broad plates of glass which reflected the sunlight and caused glare, is spoken of with disapproval.

Mr. White-Cooper, surgeon to St. Mary's Hospital, gave evidence on the eye strain through deficiency of light. During nine years 1,320 cases of overstraining of the eyes (mainly among tailors, shoemakers, and needlewomen) came under his notice. He observes :—

"The classes of persons who, according to my experience, suffer from this (*i.e.*, deficiency of light) in the greatest degree, are tailors, sempstresses, glove makers, and workers with the needle generally, who follow their occupation in ill-lighted and ill-ventilated rooms. The strain upon their eyes is great under ordinary circumstances, but especially so when they have to work on black materials. For instance, I have invariably found that a general mourning increased the number of applicants for relief at the Ophthalmic Institutions to which I am attached."

Thus we see that the modern contention, *that dark materials require a greater illumination than light-tinted ones*, was fully recognised.

Mr. White-Cooper wound up his evidence with the following remarks :—

"It has been already stated that insufficient light and bad ventilation are bad sources of mischief. These will doubtless decrease as improvements in the dwellings of the poor become more general, for the sufferers are mostly the inhabitants of miserable dark rooms, the windows of which are often purposely fastened up, and the apologies for panes of glass so begrimed with filth that light can scarcely enter. It must, however, be borne in mind that the evil of bad ventilation applies equally to the great rooms in which large numbers of workpeople are congregated together. It is in the power of proprietors of establishments of this description to prevent serious mischief to the eyes of those in their employment by making due provision for ventilation, and by carrying out such suggestions as those contained in this report as to the character and position of the lights in the rooms. It would be easy and inexpensive to arrange them in such a manner that the illumination would be good, and the workpeople not distressed by heat and glare. The vigour and energy with which work would be carried on in cool, well-lighted, well-ventilated apartments, would satisfactorily prove that attention to such points would be as conducive to the interests of the employer as to the health and comfort of the employed."

The Committee, as a result of that inquiry, made a number of recommendations, bearing on lighting, namely :—

"*That the following suffer from deficiency of light, viz., dressmakers, sempstresses, cobblers, and, in fact, all who, having to direct the needle to a definite spot, are unable to command the requisite amount of direct illumination.*

"*That the ill effects of deficiency of light are much aggravated by working long on the same material or colour. The remedies for this and the foregoing evil are, increase of light and variety of work.*

"*That flickering of light is a great evil, which is felt much by compositors and all who work at minute objects by gas illumination. The simple remedy for this is the employment of glass chimneys.*

"*It seems improper that an equal quantity of artificial light should fall on the work and on the eyes of the workman. If that is the case the latter become over-strained.*

"*This evil, when it occurs, is easily obviated by shades to the light, which defend the eye, and throw the illumination on the required object. The shades should be made of white or light coloured material, so as to reflect as much light as possible. Ground glass between the light and the worker is injurious, by intercepting and diffusing the illumination instead of directing it on the object.*

"*It seems doubtful whether heat and cold have much ill influences over the healthy eye; but when it is in a weak irritated condition, there is no doubt but that they are injurious.*"

This early appreciation of so many essential points in good lighting forms an important precedent and makes it difficult to refuse recognition to the claims of good illumination to-day.

ILLUMINATION PROBLEMS IN THE CINEMATOGRAPH THEATRE.

A SHORT time ago a paper on this subject was read by Mr. J. Frank Martin before the Pittsburgh section of the Illuminating Engineering Society.

Seeing that there are estimated to be *more than* 20,000 picture palaces in America, the problem is an important one. The loss of light in the projection apparatus is very high and the author finds that the illumination of the screen rarely exceeds 0·4 foot-candle. Any increase that can be secured in these circumstances has a considerable effect on the eye and renders the picture distinctly more easy to distinguish.

Improvements in the source of light have followed two distinct lines. Experiments have been made with 20 amp. flame arcs, and an increase in efficiency of 60 per cent. is said to have been obtained; right angle alignment of carbons is preferred. Another possible development is the use of small overrun tungsten lamps which can be placed very near the lens. It will be recalled that great claims in this direction were recently made by M. Dussaud.

On the whole the best definition seems to be obtained from plate glass screens coated with a fine white mat deposit. It is difficult to make aluminium powder screens to show up the image to the audience at the sides of the room although a marked improvement in brightness may be secured directly in front. White oil-cloth stretched on a rigid frame is less durable but quite good optically.

The intensity of illumination in the auditorium, Mr. Martin suggests, should be graduated from the screen outward from about 0·2 foot-candle to 1 foot-candle at the back where people are constantly entering. It is of course very vital in these darkened rooms to avoid anything in the nature of glare.

THE ANNUAL CONGRESS OF THE ROYAL INSTITUTE OF PUBLIC HEALTH.

(Held in Paris, May 14th-19th, 1913.)

Some Notes on the Papers dealing with Illumination.

Most of the papers at this Congress touching on illumination fell within the special section on industrial hygiene presided over by Sir Thomas Oliver. But in many of the earlier papers the importance of abundant light and air, both in the workmen's dwellings and in the crowded cities, was emphasised.

Eyestrain in the Navy.

In the section devoted to naval and military hygiene, Fleet Surgeon W. N. Whitelegge dealt with causes of eyestrain in the navy. Such eyestrain may be ciliary, retinal, or muscular. The chief causes are glare from the sea, constant living below deck under artificial light, inconvenient situation of lamps, and want of proper shades; also taxing the eyes on look-out work, and fatigue through constant use of optical instruments, telescopes, periscopes, &c.

As remedies for this prevalent eyestrain Dr. Whitelegge suggests more frequent examination of the eyes, avoidance of too prolonged work with instruments, and improved conditions in artificial light. In this last respect, at least, much remains to be done.

Miners' Nystagmus and Defective Illumination.

We have often referred to the suggestion that this defect of vision is caused by poor lighting in mines. At the Congress a paper was read by Dr. S. M. Murray who takes the same view. "At the present time," he says, "it is becoming more and more apparent that the absence of light is the main point in determining the onset of nystagmus." A paper by M. Aubrun was also read on this subject.

The Hygiene of Vision.

Dr. A. Broca, in his paper on the Hygiene of Vision, discussed the illumination required by the eye. It is only rarely that the actual brightness of illuminated objects will be excessive. The normal pupil aperture of the eye is 6 mm. in diameter, and an illumination on a white surface of even 200 lux (approx. 20 foot-candles) does not cause any appreciable contraction. But the glare from brilliant sources of light *does* do so, and Dr. Broca suggests a minimum intrinsic brilliancy of 1 c.p. per sq. inch.

As regards the amount of illumination necessary for reading, &c., he finds that the eye is giving the maximum output with an illumination of 50 lux (approx. 5 foot-candles); but with 20 lux (2 foot-candles approx.) quite a good result is already obtained. This, of course, implies a white surface: with very dark materials as much as 500 lux may be necessary.

For general illumination, where the light is merely needed for convenience to show up surrounding objects, 10 lux was considered sufficient.

Lighting as a Health Factor in Occupation and Its Influence on the Prevention of Industrial Accidents.

Mr. L. Gaster, who acted as a Vice-President of the Section on Industrial Hygiene and as a delegate of the Illuminating Engineering Society, opened a discussion on the above subject on lines which will be familiar to readers of the journal. Special mention was made of the important work before the Government Committees on industrial lighting in France and England.

Mr. Gaster finally exhibited side by side the British illumination photometer used in the Home Office tests and a similar instrument designed by Prof. Blondel in Paris. He showed that substantially the same results were obtained in both cases, and remarked that the measurement of single illumination would not be regarded as quite a simple and practicable process.

Readers who desire further details of this Congress may refer to a report in the *Journal of the Royal Society of Arts* (June 6th, 1913.)

THE INFLUENCE OF ELECTRICITY ON PLANNING AND DESIGN.

(Abstracted from a recent article in "The Journal of the Society of Architects."

A WRITER in *The Electrical Times* some months ago suggested that if it is a fact that every religion has evolved its own distinctive style of architecture, such a potent force as electricity ought to leave a heavy imprint on architecture generally, and some particularly on the planning and design of domestic and commercial buildings.

What has electricity done to change their form? What will it further do? are the questions he asks, and answers them by saying that the conservatism of both architect and householder is so deep-rooted that little or nothing has been done in the smaller type of house. Take artificial lighting, for instance. Is it not monstrous when one comes to think of it, that the means of rendering an interior visible should be left out of the reckoning when the interior is first fashioned and adorned? What do we find in the case of natural lighting? From sunrise to sunset we require daylight, and the ancient architect concentrated the best that was in him upon the fashioning of a window; he gave it many forms and adornments on it, until the window in itself typified the school of the architect without need for further enlightenment. That, however, was in the good old times when architects were born geniuses. Nowadays we make men architects by a sort of standardising process. To see the result, walk through the principal streets of London any day. Every one of those buildings is the work of a trained and experienced man, mighty seldom of a genius, hence one looks not for imagination. Now unalloyed experience did not fashion the horseshoe arch or the Doric style; it never designed a new feature for new conditions except by copying or adapting something already experienced. Hence we may have to look quite a long time for the influence of electricity on architecture.

Light creates the surroundings for man's eye, just as much as nourishment supports man's body.

"But," one hears the practised architect objecting, "show me where is the room for me to spread my bursting imagination. I can see absolutely nothing in electric lighting, cooking, or heating to alter my plans."

Yet the architect, to-day, is prepared to sacrifice considerations of prime importance in order to indulge his fancy. The proposed rebuilding of Regent Street is quoted as a case in point. The opinions of the Regent Street shopkeepers concerning the proposed plans were very antagonistic to them, "Useless lumps of stone occupying useful space," says one. "Everything depends on the run of the eye," says another. Another remarks that from certain points of view a spectator would see nothing at all but stone, and so on. Well, here is the architect deliberately outraging the first desideratum of this special type of building, and he does it in the name of his sacred imagination. The illuminating engineer and the window-dressing artist should enter a joint protest. These frontages, if they are to attract, should be an array of sweetness and light, reflecting a cheerful illumination from jewellery, hats, feathers, and fabrics on to the crowd of window-gazers that pass by. And has it occurred to the architect that, by means of an inverted moulding, even his columns might be illuminated? It must be remembered that the night display is often everything; other considerations must bow to it. There is the reflected lighting of the frontages—or direct lighting specially accommodated; there is cornice and detail lighting over

the counters; display effects should be studied outside in the stone galleries, they have a far-reaching appeal. How will the first or second-floor windows have regard to the public lighting outside? There are possibilities in these fine shops for some exquisite dreams in the way of indirect lighting—relieved, perhaps, by exposed lights here and there.

It is not always indirect lighting that has to be provided for, though generally it will now prevail. Suppose, for instance, that it became essential in any one case to imitate the stalactite roof effect of the Alhambra. The architect would do so, but would he provide means for setting an electric jewel in each of those protruding mouldings? Of course he would not.

The lighting would be an afterthought, consequently this ideal method of treating such a special case would have to be abandoned.

There are many other points and possibilities that the architect would do well to ponder over, there are ideas that the electrical engineer unaided cannot develop, such as concealing the source of artificial illumination.

Then again, shall we always have point lighting or even lighting from concealed points? Might not tubular lighting affect designs if it came into fashion? Suppose a mercury-vapour type of lamp with a good spectrum and a remarkably high efficiency were invented. This might alter the case again.

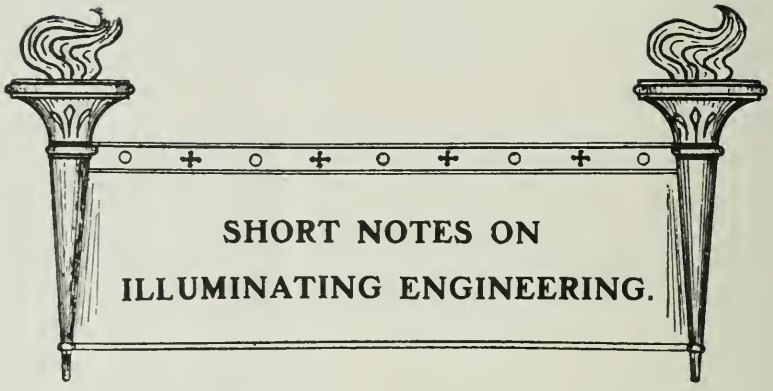
It is always assumed that the source of artificial lighting must be placed internally. But there is a type of building which has made everything else subservient to window surface with a view to obtaining every possible c.p. of natural daylight. In such a case it might sometimes be preferable to place the source of artificial light externally also.

ILLUMINATION: THE COMING QUESTION.

It is very interesting to notice how a subject will suddenly advance, apparently out of nowhere, right to the front line of public interest. The process seems mysterious, but it is generally the natural result of a long series of causes.

For instance, in the case of efficient illumination of factories, a body of men worked hard for several years to build up the new applied science of illuminating engineering. Nobody paid very much attention to them for a long time. They were looked upon as people who were making a complex technical fuss out of a simple matter of common sense. Nevertheless, they persisted, and in time they overcame the inertia of old-fashioned opinion.

Once the effect began to be visible it continued at an accelerated rate. First there was a special report by a Home Office official on industrial illumination; then came the appointment of a Home Office Committee on the subject; and during last month three papers on the subject were read before the Manchester Association of Engineers. The fact that industrial lighting has now been recognised as a prominent practical problem is a result of persistent missionary effort.—*Electrics*, February, 1913.



Recent Progress in the Moore Light.

We notice (*Z. f. B.* May 30th) an interesting account of some new patents and suggested improvements in the Moore light. As is well known the three-phase system has been somewhat widely used with this illuminant, because the flicker effect caused by the cyclical variation in the current are neutralised in this way. But there are often cases where it would be desirable to make the three secondary phases entirely independent, so that each can be used for a different room and turned on and off without affecting the others.

An ingenious method of meeting this requirement has been devised. The transformer is specially wound, the primary winding being in "mesh" while the secondary is a "star" connection. In addition the transformer is provided with a magnetic short circuit for the primary phases. This consists of alternative iron cores to the transformer which can be introduced so as to divert the magnetic flux from either windings, thus making one phase inoperative without affecting the lines of force going through the others.

Another patent bears on methods of increasing the secondary voltage. Hitherto it has been usual merely to apply the ordinary secondary pressure to the transformer. But it is now proposed to introduce a resonance effect and a spark gap so as to superimpose over the ordinary pressure a discharge having any desirable curve. By altering the nature of this curve of discharge it is said to be possible to accentuate certain lines in the spectrum of the gas and thus to alter the colour of the illuminant within considerable limits.

Another possible result of this device is the use of electrodes *outside* the tube (which have the effect of condensers). This would have the great advantage of stopping the absorption of gas by interior electrodes, and therefore rendering unnecessary the valve which is used to keep the gaseous conditions constant. The method is also favourable to the use of other gases such as Neon and Crypton; it is said that the proposed arrangement alters the colour of the former gas substantially, some green lines appearing in the spectrum so that a light of rose colour instead of the usual orange would be obtained.

The absence of interior electrodes also renders possible the use of mixtures of gas. It is hoped by the use of smaller quantities of Neon and Hydrogen and Mercury Vapour to obtain highly novel colour effects.

The Light that (nearly) Failed.

When is a lamp alight, and when is it out? This palpitating question, in the form of a constable, recently overtook a cycling friend of ours who had over-estimated the staying powers of his battery head-light. The law states no minimum candle-power, the culprit's definition is naturally elastic. A sullen glow, somewhat darker than a red-hot hairpin, was all that the lamp exhibited; the result of prolonged argument was a reference to the police inspector at headquarters. Arrived at the portals of justice, the constable reported that the lamp was to all intents and purposes extinguished, also that it was cold. It is here that we see the policeman's lack of discretion in not having attached the incriminating piece of evidence. Had he carried it himself to the station, he might possibly have demonstrated that the lamp was both cold and practically extinguished. As it was, he could only prove that it was cold. For the primary battery was of a type that partly recuperates when inverted, the electrolyte then covering the plates, and our friend the cyclist had held his lamp upside down all the way to the police station.

The answer to the question first propounded seems to be that a lamp is alight so long as any glow at all is discernible. For the inspector, who had an amateur knowledge of electric batteries, was curious to know more about the miraculous revival that had evidently taken place, and the prisoner thereupon exhibited the lamp and battery in all stages of animation and decline. The constable protested that the bright light shown on arriving at the station was absent when the arrest took place. Exhibiting the filament at a dull-red glow, the culprit asked if that represented the *status quo ante*. The constable readily acquiesced. "Well, then, the lamp was not totally extinguished," urged the prisoner. The constable asserted that such dullness was legal extinction. But the inspector hastened to disclaim responsibility for any such interpretation of the law; either the lamp was alight, or it was not alight. As the policeman admitted that it was alight, the prisoner was discharged without a stain on his character.—Meteor, *Electrical Times*, May 15.

Lighting on the Beach at the Seaside.

An enterprising step is stated to have been taken by the Felixstowe Electricity Company, who have arranged to supply current to the tents on the beach, both for lighting and boiling kettles, &c., at a fixed charge of 10s. for the summer season. No meters are to be installed, and customers can use the current when and how they please. A novel proposal!

Illumination Arrangements at the Panama Canal.

The American papers are full of the lighting arrangements to be made at the Panama Exposition. These are to be on an unprecedented scale. Over £10,000, it is stated, has been spent on experiments with cut-glass fittings designed to reflect coloured searchlight beams and give a vivid "jewel-like" effect. Another feature will be the illumination of some of the courts by means of playing fountains in which powerful arc lamps are concealed, the spray from the fountain acting as a distributor of light.

In the lighting of the colonnades and interiors of buildings indirect lighting of various hues is to play an important part. It is understood that the rather commonplace system of outlining buildings in glow lamps will be superseded by more ingenious methods, involving the illumination of the surfaces by concealed lights.

SOME ANCIENT LAMPS.

About this time last year we published an account of the wonderful collection of old lamps in the possession of Mr. J. W. Johnstone, of Hendon. By the courtesy of Herr A. Bosenberg, we are now able to describe a few lamps from the museum of his firm in Dresden, which were shown at the International Congress on Hygiene last year.

Figs. 1 and 2 are old lamps of clay, used for liquid oil and fat in the past ages. Fig. 3 is said to be a reproduction of the famous seven-limbed candlesticks described by Moses and often mentioned in the Old Testament, and used by the priests in the temple at Jerusalem. Three of the lights burned by day, the whole seven by night. After the destruction of Jerusalem Titus carried away to Rome a gold lamp of this kind valued at 40,000 marks (about £2,000).

Fig. 5 is a Jewish "Chanucka" lamp, also used in worship, and similar to many lamps employed by the Hebrews for ceremonial purposes to-day.

Fig. 4 is a specimen of the old ornamental Roman lamps. Fig. 6 seems to show the beginning of illuminating engineering. It consists of a wooden base, having mounted on it a porcelain plate to serve as a screen. (Even the oil lamps of that day, it will be noted, were felt to require screening!) The porcelain plate carries a picture of Faust embracing Marguerite, with Mephistopheles in the background.

Fig. 7 is merely an old miner's lamp, consisting of a zinc receptacle with a small canister of rape oil inside.

Fig. 8.—Old form of oil lamp, acting as a clock.

Fig. 9.—Oil lamp of 18th century. Note the shade, marking the introduction of more scientific methods.

The two lamps shown above (Figs. 8 and 9) are oil lamps. Fig. 8, made of tin, also served as a clock. The pear-shaped oil-holder was made of glass and marked with stripes indicating the hours. The falling level of the oil showed how the time passed by. Fig. 9 is a more recent oil lamp dating from about the middle of the eighteenth century. The screening of the flame from the eye quite resembles the method used with modern forms of lamps, and marks the beginning of the more scientific use of light—which, unfortunately, was too often synchronous with a decline in artistic effect.

Fig. 1.—Ancient Egyptian clay lamp.

Fig. 2.—Old clay lamp in form of a shoe.

Fig. 3.—Reproduction of sacred seven-limbed temple lamp.

Fig. 4.—Decorative Roman lamp in bronze.

Fig. 5.—Chanucka temple oil lamp.

Fig. 6.—Wooden stand lamp with porcelain screen.

Fig. 7.—Primitive miner's lamp.

REVIEW OF THE TECHNICAL PRESS.

ILLUMINATION AND PHOTOMETRY.

THE majority of contributions on illumination and photometry this month have appeared in German periodicals. Quite a number of papers on photometry were presented at recent meetings of the German Illuminating Engineering Society.

E. BRODHUN (*E. T. Z.*) gives a general summary of the position in **standards of light.** MARTENS (*L. u. L.*, June 19th), discusses the interesting problem of **diminishing illumination according to a fixed law.** It is a curious fact that there are few convenient and trustworthy methods of altering the illumination derived from a distant source, except by moving the photometer further away and using the inverse square law.

The use of dark glasses is sometimes attempted, but is rather a makeshift device, while other methods such as the use of nicol prisms and the rotating sector can hardly be conveniently used in practice. The great majority of photometric measurements are made on the basis of the inverse square law. The cosine law is also occasionally utilised, but is less trustworthy. One method referred to by Martens as having possibilities is as follows:—One may produce a uniformly illuminated surface and then obscure it to a greater or less degree by some form of adjustable shutter. For this purpose the inside of an Ulbricht globe has been employed; but for approximate work, as in the case of the Holophane Lumeter, a less elaborate method of using this principle is preferable.

B. MONASCH points out some deficiencies in the information commonly furnished on **lamps and reflectors used for automobiles.** The consumption of gas or electricity is rarely stated and the figures given for the candle-power are often decidedly vague.

W. VOEGE continues his able series of articles in *Licht und Lampe* dealing with the radiation of artificial illuminants compared with daylight. Previous articles have dealt mainly with colour and the visible rays and he now passes on to the **ultraviolet rays** and **heat radiation.** On the former point he quotes researches made by Bell and others which support his contention, that little injury need be feared from these rays if illuminants are used with reasonable care. On the other hand, when working at close quarters with sources which are very rich in ultraviolet energy, some form of protection certainly seems desirable. It is curious that no general agreement has yet been reached as to the best method of testing the physiological effect of ultraviolet rays. Most methods are based on the effect on photographic paper. VOEGE gives the results of a test of this kind, according to which 38 per cent. of the visible and ultraviolet spectrum of daylight takes the form of chemical rays, while with the magnesium light this percentage rises to as much as 70 per cent.

Another article of more than common interest dealing with the physiological effects of light occurs in the *Zeitschrift für Beleuchtungswesen* for June 20th. An abstract is given of some researches by BROSSA and KOHLRAUSCH on the electrical current in the eye following an exposure to light. This is interesting, because it suggests a method of comparing the effect of different portions of the spectrum, and their possible influence in causing fatigue. For example, it is found that the most pronounced effect occurs in the yellow with the light-adapted eye, in the green with the dark-adapted eye. This is exactly what our knowledge of the sensitiveness of the eye at high and low illuminations would lead us to suspect.

Finally, reference may be made to a short article in *Licht und Lampe* on the **effect of light in causing shadow.** A series of photographs of a cast of the Laocoon head illuminated respectively from above and below and from the two sides, is given. In all cases there is marked distortion of the expression. It is pointed out that to show up statuary properly, light coming from all directions and giving soft shadows is usually needful. Light coming from a single direction almost always leads to inartistic and incongruous effects.

GAS AND ELECTRIC LIGHTING.

There are not many articles to record in this section. A. Rossel (*Z. f. B.*) June 10th, discusses the now familiar problem of the **comparative economy of arc lamps and high candle-power tungsten lamps.** He finds that when units of moderate candle-power are required, the metal filament lamp comes out cheaper; but when very powerful light is needed the flame arc is still supreme.

Several of the German papers refer to a **new form of "artificial daylight" lamp** produced by Siemens and Halske. It utilises a tungsten lamp and a special glass screen which, however, only absorbs with progressively increasing strength, rays of wave length between $0{\cdot}48\mu$ and $0{\cdot}62\mu$; while not designed to give a light *exactly* equivalent to daylight, the lamp is stated to resemble it very closely for practical purposes. The specific consumption is given as 1·4 watts per candle. Seeing that the absorption of screens used for this purpose has hitherto been in the neighbourhood of 80 per cent. it would seem that these lamps have a much greater efficiency than most of those designed to produce artificial daylight. The question remains how far it is desirable to sacrifice accuracy of colour to efficiency of consumption.

In the *Electricien*, June 14th, an account is given of a new method of obscuring lamp bulbs. Most forms of lacquer tend to become yellow in course of time, and etching with hydrofluoric acid is apt to be prejudicial to the eyes of the operator unless care is taken. The new "Eak" process is said to be free from these defects.

Attention might next be called to an article on the **electric lighting of churches** (*L. u. L.*, July 3rd). One illustration is shown of a large church lighted by arc lamps. This is something of an innovation. It is claimed, however, that this method is well adapted to large interiors, and that the high value of illumination obtained is very useful in showing up richly decorated walls and ceilings.

There are few articles dealing with illumination by gas this month. A contribution in the *American Gas Light Journal* on "Stimulating The Gas Lighting Business" emphasises the value of illuminating engineering as a weapon to salesmen and makes a number of suggestions as to the number of lamps to be provided for various interiors. The same journal contains an article comparing the cost of gas and electricity for indoor illumination which follows fairly familiar lines.

In the *Revue des Eclairages* there is an account of the illumination of post offices by acetylene, and in the *Zeitschrift für Beleuchtungswesen* a description of a method of applying benzol vapour at high pressure to incandescent mantles. This is said to give very efficient results.

LIST OF REFERENCES.

Illumination and Photometry.

Brodhun, E. Ueber Lichteinheiten (*E. T. Z.*, June 26).

Brossa & Kohlrausch. Ueber Netzhautröme bei Beleuchtung mit homogenem Licht (*Z. f. B.*, June 20).

Eitner, P. Bericht des Lichtmessausschusses (*J. f. G.*, June 28).

Lummer, O. Die Bestimmung der wahren Temperatur der Glühlampen (*Licht und Lampe*, June 19).

Martens. Photometrische Schwächungsseinrichtungen (*Licht und Lampe*, June 19).

Monasch, B. Misstände in der Automobil-Beleuchtung (*Licht und Lampe*, June 19).

Vaughn, F. A. Library Illumination (*Elec. World*, June 14).

Voege, W. Die Strahlung unserer künstlichten Lichtquellen im Vergleich zu einander und zum Tageslicht (*Licht und Lampe*, June 5, 19, July 3).
Beleuchtung und Kunst (*Licht und Lampe*, July 3).

Gas and Electric Lighting.

Meyer, W. Die Schwankungen der Lichtstärke bei von wechselstrom gespeisten Glühlampen und Mittel zur Unterdrückung derselben (*Elek. u. Masch*, June 15).

Recklinghausen. A propos des lampes à vapeur de mercure et de leur emploi au redressement des courants alternatifs et à la sterilisation (*Bull. Soc. Int. des Electriciens*, April).

Rossel, A. Bogenlampen oder Metallfadenlampen (*Z. f. B.*, June 10).
Die Erzeugung Künstlichen Tageslichtes (*Z. f. B.*, April 30).
Halbindirekte Beleuchtung durch die Indralampen (*Z. f. B.*, April 30).
Depolissage des lampes à incandescence au moyen du produit "Eak" (*Electrician*, June 14).
Glühlampen mit dem Tageslicht gleichen oder ähnlichen Licht (*Licht und Lampe*, June 5, *Z. f. B.*, April 30).
Die elektrische Beleuchtung von Kirchen (*Licht und Lampe*, July 3).
Benzol Presslicht (*Z. f. B.*, April 30).
Gas *v.* Electricity for the lighting of Buildings (*Am. Gas Light Journal*, June 16).
Stimulating the gas lighting business (*Am. Gas Light Journal*, June 16).
L'éclairage des Bureaux de Postes à Acétylène (*Rev. des Eclairages*, June 30).

CONTRACTIONS USED.

Elek. u. Masch.—*Elektrotechnik und Maschinenbau.*

E. T. Z.—*Elektrotechnische Zeitschrift.*

J. f. G.—*Journal für Gasbeleuchtung.*

L. u. L.—*Licht und Lampe.*

Z. f. B.—*Zeitschrift fur Beleuchtungswesen.*

REVIEWS OF BOOKS.

Lehrbuch der Photometrie. By F. Uppenborn. Edited by Dr. B. Monasch. (R. Oldenbourg, Munich and Berlin, 1912, Mk. 15.)

Dr. Friedrich Uppenborn, who died in 1902, was known to scientists throughout the world as an indefatigable worker in photometry, and after his death it was felt that his unfinished work on this subject should not be lost. To Dr. Berthold Monasch was entrusted the task of editing it, and bringing the material up to date—a work which he has ably carried out.

It may be said that this book, while naturally assuming expert knowledge, is distinctly more readable in style than most treatises on photometry. In addition the type is large and the matter not too crowded. The first chapter deals with the human eye, and includes some account of the theory of the rods and cones (which, by the way, seems now to be less generally accepted than it was a few years ago). Reference is made to Voege's researches on heat rays and ultraviolet light.

We are next taken through the customary treatment of units and standards, a somewhat special feature being the table enabling the M.S.C.P. to be calculated in the case of sources of various shapes and sizes (points, lines, cylinders, &c.). Distribution and illumination curves are treated very fully and some information is given as to the light derived from oil lamps. There is an excellent table comparing the specific consumption (watts per lumen, on the working plane) of various methods of lighting. The treatment of illumination photometry is fairly complete. The only fault we have to find being that the author has practically confined himself to German forms of instruments.

The treatment of colour photometry and its difficulties is distinctly good, and up to date, and the final chapter on the photometry of searchlights will be useful to many who have not clear ideas on this subject.

Electric Wiring. By W. C. Clinton. (John Murray, Albemarle Street, London, W.C. Third Edition, 1913. 2s.)

This little book is intended as an introduction to wiring, and for those preparing for the Preliminary Examinations of the City and Guilds of London Institute.

The first chapter deals with fundamental principles, and the author then passes on by simple stages to electric light and bell circuits, conduits, fuses, insulating materials, &c. There is also a short—some might, perhaps, think unduly short—section on illumination. The book is well supplied with diagrams and worked examples of wiring calculations, and the fact that it has reached a third edition shows that it fulfils a distinct need.

TRADE NOTES.

[At the request of many of our readers we have extended the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

GRAETZIN LIGHT.

At the works of the **British Graetzin Light, Ltd.** (Graetzin Works, Chapter Street, S.W.), quite a number of new models can be seen. Foremost among these are the fixtures utilising the "Triumph" Graetzin low-pressure lamp which is stated to give an efficiency of no less than 47 candle-power per cubic ft. of ordinary low pressure. This lamp is built in a form suitable for shop and factory lighting, &c., and can also be obtained in a more decorative style surrounded by the light glass stalactites very largely employed on the Continent.

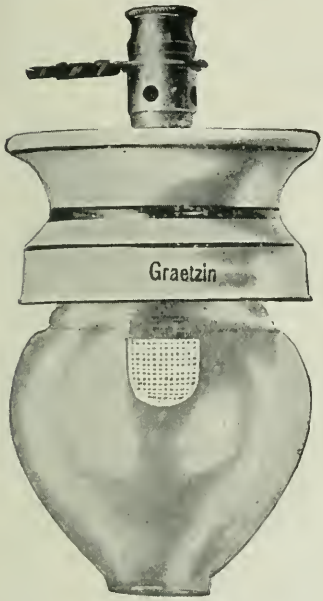


Fig. 1.—Graetzin "Baby" Burner. (Consumption 0·5-0·7 c.f. per hour.)

There are also on view a number of small units some of them very small and compact. The Graetzin "Secunda" burner is stated to give about 60 candle-power at 2 cubic ft. per hour, while the Graetzin "Baby" burner gives 10 candle-power and consumes only 0·5 to 0·7 cubic ft. per hour. (See Fig. 1.) This unit is expected to be of great service for lighting corridors, small landings, &c., where only quite a small light is required. The complete burner and globe is only 4 in. deep and 2½ in. wide. The new pattern workshop burner contains an ingenious device for protecting the mantle by a strong metal frame which renders globes unnecessary. The frame can be removed, carrying the mantle with it, so that there is no need to touch the mantle with the fingers at all, thus removing one fruitful source of breakage. (See Fig. 2.)

An interesting novelty was shown by this firm at the Exhibition of the International Roads Congress at the Horticultural Hall. This is a low-pressure lamp giving 300 candle-power with a single mantle, and does not consume more than 7 cubic ft. per hour. The whole lamp can be lifted out of the lantern in a few minutes. The fitter can therefore exchange it for a new lamp and carry away the defective one for repair, without interfering with the post carrying the lamp in any way. The arrangement also makes it possible to use an ordinary lantern with square panes.

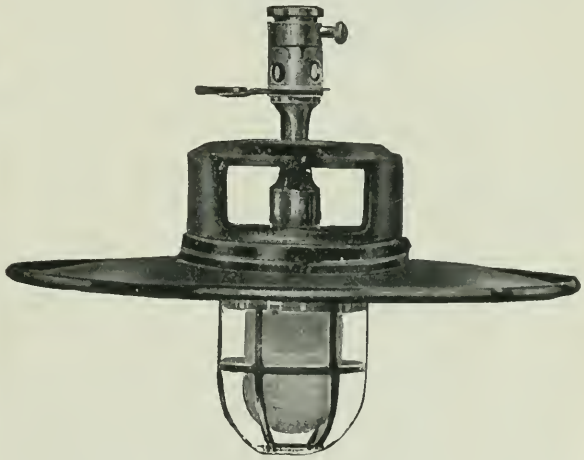
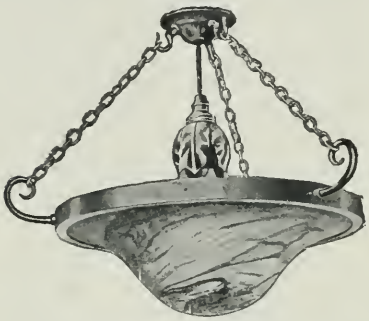


Fig. 2.—Graetzin Workshop Type of Burner. The mantle is removed with the metal guard and need not be handled with the fingers.

The high efficiency secured is mainly ascribed to the elaborate preheating arrangements in the lamp, the gas having quite a long travel past the heated parts. It is well known that lamps of this kind are rather subject to the effect of draughts and wind, but in this case, it is stated, the defect has been completely overcome. Quite a strong blast of air can be directed on the top of the lamp without any prejudicial effect.

FITTINGS FOR SEMI-INDIRECT AND INVERTED ILLUMINATION.

Another illustration of the taste for lighting of this kind comes from **Messrs. Siemens Bros.,** Dynamo Works, Tyssen Street, Dalston, who have sent us a catalogue of their semi-indirect pendants. Many of these are highly decorative, and good effects can be obtained by the use of special marbled glass of the type shown in the accompanying illustration. We notice that the new Holophane semi-indirect unit is also listed. There are also fittings using alabaster and other types of glass as well as the simpler dust-proof types intended for office work.



An attractive Siemens semi-indirect Fitting using Coenix Glass.

Another catalogue from Messrs. Siemens refers to their special line of weatherproof lanterns and street lighting fittings. Of special interest are those intended for the conversion of gas lanterns, and equipped with special enamelled reflector, designed to distribute the illumination from the metal filament lamp more uniformly down the street. There are also special waterproof lanterns for side streets, stations, shops, etc. One promising method takes the form of enclosing a Holophane reflector and lamp inside a waterproof outer globe. This should effectually do away with any trouble due to the deposit of dirt and enables the unit to be used for outdoor work.

Another booklet issued by this firm is devoted to illuminated signs and flashers, which are now playing an important rôle as an advertising medium.

SEMI-INDIRECT GAS LIGHTING UNITS.

In a recent number we drew attention to the new Pedestal Fittings devised by **Messrs. Sugg and Co.** (67, Regency Street, S.W.). This is only one among many new types of gas fittings introduced by this firm. A recent visit to their Show Rooms made it clear that semi-indirect lighting with gas is making strides. Besides the familiar simple types adopted for office lighting there are now more decorative styles of fixtures using marbled and opal glass which are said to achieve practically all that electric lighting can do. This need not be wondered at, for we believe that Messrs. Sugg and Co. have also manufactured electric light fittings for quite a number of years, being responsible among other installations for those newly introduced into Westminster Abbey. We hope on another occasion to give some further details on some of these novelties.

INDIRECT LIGHTING IN A TEA ROOM.

Good lighting is an asset of tremendous value in the catering business. People are constantly on the look out for something attractive and new, and much interest has been taken in the indirect and semi-indirect systems of lighting now being widely introduced in this country.

The illustration on the opposite page shows a tea room lighted by the B.T.H. "Eye-rest," indirect system.

The lamps are completely hidden by the opaque bowl and the fitting itself is finished off in a decorative style adapted to the somewhat bizarre nature of the room.

The **British Thomson Houston Co.** have also installed this system in the Temple Speech Room at the famous school at Rugby. A number of fittings with a total wattage of 4,200 are used, and are fitted with contact suspension gear so that they can be lowered to the ground for cleaning. The room is fairly lofty, but it is stated that the pictures on the lowest part of the room are excellently lighted.

INDEX, August, 1913.

Subjects.	Authors.	PAGE.
Architectural Design, Influence of Electricity on		434
Editorial	L. Gaster	407
Factory Lighting, Report of H.M. Chief Inspector		429
Illumination, in trades affecting the Eyes		430
Illuminating Engineering, Short Notes on		436
Interior Illumination, Notes on	H. Bohle	411
Lecture Theatre, Lighting of a	C. E. Greenslade	417
Old Forms of Lamps		438
Reflectors and Globes, Notes on	A. Blok	419
Reviews of Books		442
Review of the Technical Press		440
Royal Institute of Public Health, Annual Congress		433
Trade Notes		443

A Tea Room lighted on the B.T.H. "Eye-Rest" System.
The fittings were specially designed to match the decorative scheme of the room.

THE

Holophane Lumeter.

THE simple, portable, and accurate apparatus for measuring illumination, surface-brightness, or reflecting power.

Can be carried from place to place with the ease of a small hand camera.

Dimensions only $5\frac{3}{4}$ in. × $4\frac{1}{2}$ in. × $1\frac{3}{4}$ in; case and accumulators supplied.

Measurements from 0·01 to 2000 foot-candles can be made.

Showing general appearance of new model of Holophane Lumeter.
(Dimensions : $5\frac{3}{4}$ in. × $4\frac{1}{2}$ in. × $1\frac{3}{4}$ in.)

The Holophane Lumeter is of value not only to lighting engineers, but to architects, medical officers, factory inspectors, photographers, and many others.

Among the users of this instrument may be mentioned :—

The House of Commons, The Home Office (Factory Dept.), The London County Council, General Post Office, Great Western Railway, L. & S.W. Railway, Underground Railways, The Gas Light & Coke Co., St. James and Pall Mall Electric Supply Co., The Union Electric Co., The British Thomson-Houston Co., &c., &c.

For all particulars apply to

HOLOPHANE, LTD.,

12, Carteret St., Queen Anne's Gate, S.W.

The ILLUMINATING ENGINEER
ELECTRICITY · ACETYLENE · OIL · GAS
Edited by LEON · GASTER

THE JOURNAL OF SCIENTIFIC
ILLUMINATION.
OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London, 1909.)
ILLUMINATING ENGINEERING PUBLISHING COMPANY, LTD
32, VICTORIA STREET, LONDON, S.W.
Tel. No. 5215 Victoria.

EDITORIAL.

The Regulation of Traffic and the Lighting of Streets.

On pages 458 to 462 of the present number we give an account of the proceedings of the International Road Congress, held in London on June 23rd to 28th. At this Congress a special section was devoted to the lighting of public highways and vehicles—a matter of considerable importance to traffic authorities.

It will be observed that, by the very fact of this special section on lighting being included in the programme, the Congress tacitly assented to the view that the illumination and upkeep of roadways should be considered together. We lay stress on this matter in view of the important report since issued by the Select Committee on London Traffic. In recommending the formation of a joint traffic board for London the Committee recognised that the traffic conditions in this city require general treatment by a central authority, and we think that an equally good case might be made out for similar treatment of public lighting. At present, as is well known, the lighting provided in any section of London rests with the local authorities,

some of whom have evidently still to realise the necessity for a more generous view of what constitutes good illumination. Logically the nature and amount of illumination required should be determined by the character of the street to be lighted and the amount of traffic it has to carry. We should like to see an attempt to ascertain the best methods of lighting, and a more uniform system throughout London, in place of the heterogeneous variety that exists at present. We hope, therefore, that when the new board comes into existence it will bear in mind the fact that lighting is an essential element in the guidance of traffic, and by its action pave the way for the control of the lighting of London by a single central authority.

There is also the question of the lighting of country roads, which was the subject of much discussion at the International Road Congress. Here again, the diversity of lighting even on main roads is remarkable, and depends entirely on the views taken by the parish through which it happens to pass. The lighting of these main thoroughfares is becoming a most important matter to motorists, and they have already been opened up for speedy long distance traffic to a remarkable extent. The purpose of such roads is becoming quite different from what it was in the days of slow moving local traffic over short distances, and the lighting should be developed accordingly.

Several of the speakers expressed the hope that in years to come these important roadways would be lighted on some uniform system under national control. There is also a need for international agreement on the use of illuminated sign posts and standard methods of indicating obstacles, level crossings, sudden turnings, &c., on these roads. If some of the money derived from the taxation of motors were devoted to the illumination of danger signals by night, and if some of the scouts who patrol the roads were told off to attend to their maintenance, this in itself would be an excellent beginning. But all such matters should surely come eventually under the control of some central national authority.

The Physical Laboratory of the National Electric Lamp Association, U.S.A.

A short time ago we referred to the work of the well-equipped laboratory of the National Electric Lamp Association at Cleveland, Ohio,* under the supervision of Dr. E. P. Hyde. We expressed the hope that an account of the work of this laboratory since its organisation about four years ago would be presented shortly, and we note that an abstract bulletin of the research work carried on by the staff has since been published. In the Franklin Institute Journal for July, 1913, a paper on the work of the laboratory has also been published by Dr. Hyde, so that we have now information as to what has already been done and what is proposed for the future. It is interesting to observe that considerable extensions to the laboratory are being made.

---

* *Illum. Eng. Lond.*, Vol. V., 1913, p. 449.

Now that the question of international agreement on the practical aspects of illumination is coming to the front, the co-operation of laboratories of this kind would be most useful, and it is most important to form a clear idea in each case of the character of work to be done. There is certain work connected with standards of light, units, &c., which is already adequately undertaken by the recognised laboratories in the chief countries of Europe and the United States. There are also a number of laboratories at colleges and technical institutions where research work on the more scientific aspects of photometry and illumination could be done under the guidance of the professors. What we at present seem to lack is a laboratory where practical experiments in Illuminating Engineering can be carried out. There are now many questions, such as the amount of illumination required for various industrial purposes, the best methods of suppressing glare, the relative merits of direct and indirect lighting, the avoidance of shadows, &c., on which authoritative impartial information is badly needed. It is probable that the work of the British and French Governmental Committees on Illumination will suggest a number of points on which detailed information and corroborative tests would be of service. We venture to hope that the laboratory of the National Electric Lamp Association will turn its attention to some of these points, and we have reason to believe that the proprietors of the laboratory would be entirely favourable to such a course. By so doing it would earn the gratitude of many of those in Europe who are at present wanting information on these matters and would justify the splendid financial support received.

International Medical Congress.

At the International Medical Congress held in London last month there were several contributions dealing with illumination and the eye.

The paper read by Mr. J. Herbert Parsons (Vice-President of the Illuminating Engineering Society) dealt mainly with affections of the eye produced by excess of light, which are termed by him "Photophthalmia." Under this heading came such effects as snow blindness, eclipse blindness, the inflammation caused by exposure in electric welding, &c. The paper contained a very complete series of references to the effects of sunlight and the ultra-violet and infra-red rays, and the study of this invisible radiation is now being most energetically taken up. We notice that in researches on these subjects the physical and physiological aspects are now much more frequently considered together. This is surely one valuable result of the illuminating engineering movement.

The discussion of this paper had a decidedly practical bent, several speakers referring to the glaring effect of unscreened powerful lamps outside shop windows. There are plenty of obvious defects of this kind still prevalent which deserve the censure of medical authorities. On the other hand the question of the effect of the invisible radiation from modern illuminants is a very complicated one. It is evident from the paper by Mr. Parsons

that much remains to be discovered in this field, and it is best at present to imitate his discretion, and to avoid sweeping statements as to the comparative effects of the different illuminants.

We should next like to refer to the paper read by Dr. James Kerr, who is also known to our readers as a member of the Illuminating Engineering Society, and as Chairman of the Joint Committee on School Lighting. Dr. Kerr gave evidence as to the prevalence of visual defects among school children and the evil influence of too much "close work." He also mentioned imperfect lighting as another cause of defective vision among school children and remarked that there were still too many schools in which the lighting was badly arranged, with the result that inconvenient shadows were cast on the desk by bodies of the children. Dr. Posek (Ganz, Austria) also emphasised the importance of good natural and artificial illumination. In the course of his remarks Dr. Kerr mentioned some of the recommendations embodied in the recently issued Interim Report on the Artificial Lighting of Schools.

The importance attached to good illumination at this important international congress, which received so much attention in the Press, was very gratifying and should lead to a wide interest being taken in this subject, both by the medical profession and the general public.

Illumination required for needlework with dark materials.

Another point that should certainly be brought before the notice of school authorities is the necessity for a specially high illumination in classrooms where needlework with dark materials is carried on.

It will be recalled that in the Report of a committee appointed by the Royal Society of Arts as far back as 1855, which was referred to in our last number,* special stress was laid on this point in connection with the tailoring trades, where dark materials are often employed. A very curious circumstance, mentioned by Mr. White Cooper, surgeon to St. Mary's Hospital, was that the number of cases of eyestrain among workers in these trades increased considerably during periods of national mourning. This was ascribed to the change of work to dark stuff, carried through as a rule at short notice, at considerable pressure, and involving extra work by artificial light.

Since the days this report was written the tailoring trades have developed enormously in this country, and the number of workers engaged is far greater. Conditions of stress which were then exceptional have become almost permanent to-day, and the importance of good artificial illumination is correspondingly great.

We think that those in this country who are urging the need for better methods of industrial lighting might make good use of the evidence in this report, which would no doubt be confirmed by more extensive investigations at the present time.

LEON GASTER.

---

* *Illuminating Engineer, London, August*, 1913, pp. 430—432.

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of "The Illuminating Engineer."

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

ILLUMINATION AND THE EYE.

Some Notes on the Proceedings at the XVIIth International Medical Congress, held in London, August 1913.

The seventeenth International Medical Congress, held in London last month, attracted exceptional public attention. To the medical profession the occasion is always an important one, the congress being attended by many famous Continental physiologists and physicians.

Among the papers presented there were several dealing with illumination and the eye. That by Mr. J. Herbert Parsons, in the section on ophthalmology, dealt specially with the evils of excess of light, while several others in the section on Hygiene and Preventive Medicine, discussed the lighting of schools.

Affections of the Eye produced by undue exposure to Light.

Among the many phenomena under this heading Mr. Parsons mentioned snow-blindness, ophthalmia electrica, lightning cataract, glassworker's cataract, and eclipse-blindness.

At one time all these effects were put down merely to excess of light, but Mr. Parsons shows that we must also consider the *quality* of the radiation. The physiologist of to-day must also study the physics of light in order to understand his subject. Thus a man who suffers from snow-blindness after wandering in the mountains, a worker at the glass furnace who becomes a victim to cataract, and an electrical engineer whose eyes have been temporarily blinded by the flash of a short circuit, may be suffering from the effects of different qualities of radiation and may presumably require distinct treatment.

Visible and Invisible Vibrations.

The visible spectrum of sunlight extends from about 723 $\mu\mu$ in the red to 397 $\mu\mu$ in the violet. But there is a vast region of infra-red rays extending beyond the red to 60,000 $\mu\mu$, and beyond the violet there are rays existing as far as 100 $\mu\mu$. In the same way the radiation of artificial illuminants contains a varying percentage of visible rays, some of them (such as the Schott Uviol mercury lamp) being very rich in the ultra-violet.

Mr. Parsons gives a long list of references to investigators who have studied the effect of ultra-violet rays on the eye. Some of these rays are absorbed by the lens and cornea and may therefore affect their structure in course of time. Researches on the absorption of the infra-red rays have given more discordant results, but in view of the enormous preponderance of this radiation in most artificial illuminants, their effect should certainly be more closely examined.

In order to describe generally the inflammatory effects of excessive light Dr. Parsons has coined the term "photophthalmia." He gives a long list of authorities on this effect— from Xenophon onwards. It appears that there is now very little doubt that this effect is due mainly to ultra-violet rays, which are so

strongly present in the light at high altitudes.

Experiments on animals by Widmark with sources rich in ultra-violet rays have shown that inflammation of the eyes and opacity of the cornea are brought about almost entirely by these rays, and the participation of the luminous rays in this effect is believed to be relatively slight.

Effects of Artificial Light.

"Photophthalmia," in the form of *ophthalmia electrica*, has long been known as an effect produced by incautious exposure to naked arc lamps, *e.g.*, in connection with electric welding, and Birch-Hirschfeld has reported cases of similar effects caused by Uviol and quartz tub mercury lamps. The victims were chemists and photographers.

The injury to the eyes arising from the flash of short circuits is sometimes complicated by the passage of electricity through the body, and is not unlike the effect of lightning.

The slowly produced cataract of glass-workers has sometimes been ascribed to the ultra-violet rays from the furnaces; but as these rays are not present in any large proportion some investigators ascribe the cataract to the drying influence of the enormous heat. It is probable that the infra-red rays are here not without effect.

It is possible that the considerable amount of research work going on in this field may lead to important inferences as regards the effect of artificial illuminants in ordinary use. Several of the speakers in the discussion referred to the effect of glare from unshaded brilliant lamps, as exemplified in some varieties of shop-lighting, and it is a good thing that these matters are now being brought before the notice of the medical profession. (A Summary of this discussion appears in the *Brit. Medical Journal* for Aug. 23rd).

The Eyesight of School Children.

Dr. James Kerr, Medical Officer to the London County Council, dealt with the causes of visual defects of school children. He suggests that they are due in a large measure to our system of education, much of which "has survived from the literary and clerical schools of the Middle Ages." There is undue insistence on reading and writing by young children. Dr. Kerr thinks that no child should even make letter-forms, whether printed or written, before the seventh or eighth year, and even after that period work on a large scale is preferred.

Reference is also made to the equipment of the school, the choice of suitable desks, &c., and the need for effective lighting and ventilation. In this connection Dr. J. Kerr quotes the interim report of the committee composed of members of the Illuminating Engineering Society and other bodies, of which he acted as chairman. An illumination of $2\frac{1}{2}$ foot-candles on the desks and 4 foot-candles on the blackboard is recommended. The eyes of young children are specially sensitive to excessive brightness, and some form of "glare-test" would be very useful.

Although the lighting of schools has improved of late years, there is still much room for improvement, the existence of "back-lighting," leading to the children sitting in their own shadow, being a common defect.

Another paper dealing with the eyesight of school children was read by Dr. R. Posek (Ganz, Austria). He, too, insists on the need for good lighting, and suggests a minimum of 10 metre-candles (about 1 foot-candle). Judged by the views of authorities in England this would appear a somewhat low value, but the author has in view the enormous daylight variations to which a schoolroom is subject, and gives the above figure as the absolute minimum on the worst lighted desk.

Among other papers dealing with the eye we note that of Dr. Karl Grossmann, who advocated more stringent tests of the eyesight of sailors, and suggested that a committee should be appointed to report upon the matter at the International Ophthalmic Congress to be held at St. Petersburg next year.

A MODERN OFFICE LIGHTING INSTALLATION.

During the last month the entire work of *The Illuminating Engineer* has been

Fig. 1.—A view in the extension of the Editorial Offices of *The Illuminating Engineer*, lighted by Holophane semi-indirect units.

transferred to 32, Victoria Street, the affairs of the journal and the Illuminating Engineering Society being now conducted exclusively from Mr. L. Gaster's office. This centralisation of the work will, it is hoped, prove a great convenience. As the lighting of these rooms has been recently arranged and comprises both direct and indirect illumination, the accompanying views of the offices, taken entirely by artificial light, should be of interest.

The room shown in Fig. 1 is approximately 22 feet long and 16 feet broad, and is chiefly used for editorial work. It is also utilised occasionally for meetings of the Council of the Illuminating Engineering Society and Committees. The illumination is provided by two Holophane satin-finished semi-indirect fittings, each of which contains a 100-watt lamp. The illumination is uniformly distributed over the room, the value over the desk and tables being about over 3 foot-candles. The bookcases are mainly devoted to a collection of works on illuminating engineering, and the walls are lined with photographs of various lighting installations. The semi-indirect system is very suitable for the illumination of such vertical surfaces.

Two views of this room are shown in Figs. 1 and 2. There is also a well-shaded lamp to the left of the desk for local lighting. In the far corner, on the revolving bookcase, is a Holophane unit mounted on a bronzed pedestal. The table in this corner is covered by some of the series of journals and Transactions of Societies regularly received in exchange for *The Illuminating Engineer*.

Fig. 4.—View of the Assistant-Editor's Room. The large shelf contains accumulated "exchange" literature and is lighted by a Holophane Uniflux reflector.

The next illustration (Fig. 3) shows the main central office, next door to the

Editor's room, in which the correspondence and routine work of the journal and the Illuminating Engineering Society is transacted. This room is lighted by a central Holophane sphere containing a 100-watt lamp. In the background will be seen a desk lighted by two of the Holophane "Bank" units, each consisting of a tungsten lamp in Holophane reflector, covered by an opal shade (white inside and green outside). On the left is a drawing board, where tracings, &c., are carried out, illuminated by a 30-watt tungsten lamp in an opaque cardboard reflector.

Through the open doorway a glimpse may be caught of another room, chiefly used by the Assistant Editor, where the journals and literature are stocked away as they come in. The final illustration (Fig. 4) shows some of the cases in which this matter is kept. The main illumination is provided by two 60-watt lamps in Holophane reflectors, mounted direct on the ceiling. A Holophane Uniflux reflector serves to illuminate the large bookcase in the background.

It is the aim of *The Illuminating Engineer*, with its international connection, to become the centre for information on all matters connected with illumination. Corresponding members of the Society and friends of the journal passing through London will receive a cordial welcome at 32, Victoria Street.

VIOLET RAYS IN ZINC MINING.

According to a recent number of *Popular Electricity* an interesting application of violet light is to be found in the separation of zinc from the mineral willamite. The ore consists of a mixture of silicate of zinc and calcite. There is considerable difficulty in separating these materials, which by ordinary light both appear to the eye to be of an identical shade of grey. But under a strong violet light the zinc silicate fluoresces to a brilliant turquoise hue while the calcite retains its original colour. The violet ray is now used in the concentrating mills. It is also employed in the underground workings to determine just where the ore is located, each miner being provided with a portable apparatus for producing the required light.

A FRENCH JOURNAL ON ILLUMINATION.

It is but a short time since we announced the formation of a German Illuminating Engineering Society, and we are now interested to note the issue of a new journal dealing with illumination in France. The journal is under the direction of Prof. Blondel, whose long connection with illuminating engineering will be known to all our readers.

The first number of *Science et Art de l'Éclairage* appeared on the 1st of June, and contains a number of readable articles. M. R. Chasseriaud contributes an editorial summarising the aims of the *Revue*, Prof. Blondel deals with photometric units, and M. Rougier has an article on the mesophotometer.

We wish our contemporary every success. This new journal will doubtless afford an authoritative source of information on developments in France, and will enable us to keep our readers in touch with the latest progress in that country.

FIG. 2.—Another view of the Editorial and Reception Room of *The Illuminating Engineer* (Mr. Gaster's Office).

FIG. 3.—The General Office of *The Illuminating Engineer*, lighted by central Holophane sphere and subsidiary units.

INDIRECT CHURCH LIGHTING.

In this country the indirect method has not as yet been widely applied in church lighting. The conditions are not always favourable, owing to the great height of the ceiling and comparative darkness of the surroundings in many of our older churches and cathedrals. There is also the question whether modern styles of lighting are suitable for buildings of an ancient type. The interiors of cathedrals and vast religious buildings were necessarily dimly lighted in the past, and this subdued illumination has become, to some extent, associated with religious feeling. A very bright illumination, even if excellent from the practical and artistic standpoints, might still not be considered suitable in a church.

But in the case of more modern buildings, where a white ceiling will probably be available, the conditions are somewhat different, and the excellent photograph on the page opposite shows what has been done in this way in the United States. The Eberhardt Memorial Church (Mishawaka, Ind.) appears to be essentially modern and is said to have a very distinctive moulded white ceiling, excellently adapted for reflection of light. From this ceiling seven large indirect X-ray units are hung. The central fitting contains sixteen 150-watt lamps. The other fittings are provided with a somewhat smaller number (most of them four 150-watt lamps). From an article on this installation in the *Lighting Journal* it appears that the area of the auditorium is 2,550 square feet, and that it receives upwards of 5,000 watts; so that the consumption might be put at about 2 watts per square foot.

Six fixtures lighting the auditorium hang about 80 in. from the ceiling, which is about 40 ft. from the floor. Besides the central fitting, there is one unit over the pulpit, two in the nave, one over each of the two transepts, and one over the gallery. Smaller units are provided under the gallery. The style of the fittings is specially selected to harmonise with the building, and the absence of glare and restful effect are spoken of as good features. A special winch is provided in order to enable the large units to be lowered for cleaning purposes, or for the replacement of lamps.

THE GAS INDUSTRY AND ILLUMINATION.

Observers of the trend of current events in connection with the industries which supply the agents from which artificial light is obtained, cannot fail to have noticed that the utilisation of light in the most scientific fashion, so as to obtain from it the utmost in valuable illumination effect, is a subject that can no longer be ignored.

If anyone thinks the matter is merely an abstract or a sentimental one, and will have no effect on the lighting industries in the future, let him read the digest of the report of the Illuminating Engineering Society, published in our columns to-day. There is all the evidence there that neglect will eventually meet its due deserts.

Where the technical bodies of both the gas and electric industries have not hitherto laboured, the Illuminating Engineering Society have entered and, we willingly agree, have been operating with good effect.—*Journal of Gaslighting*, June 10th, 1913.

FIG. 1.—A view of the Eberhardt Memorial Church Mishawaka (Ind.), U.S.A., taken by artificial light and showing the use of indirect illumination. For this excellent photograph we are indebted to the courtesy of the National X-ray Reflector Co., of Chicago.

LIBRARY LIGHTING.

The report of the Joint Committee of the Illuminating Engineering Society and the Library Association on the Artificial Lighting of Libraries published in our July number has attracted much attention.

The report is reproduced in the *Library Association Record* for July 15th, and this official journal will doubtless bring the matter to the notice of many libraries throughout the country.

THE ILLUMINATION OF PUBLIC HIGHWAYS.

Some Notes on the Proceedings at the International Road Congress held in London, June 23rd-28th, 1913.

The fact that illumination deserves to be considered as part of the upkeep of the highway was emphasised at the International Roads Congress held in London last June. A special section was devoted to the lighting of public highways and vehicles, no less than nine papers on this subject, by delegates from seven different countries, being presented.

On pages 459-462 we give a summary of these papers.

Resolutions on Lighting.

The following series of resolutions put forward at this meeting also serves to show the interest which is now being taken in the subject :—

1. *For the purposes of a general determination of methods of lighting highways may conveniently be divided into three classes as follows :—*

(1) *Important streets in Cities, Towns or other urban areas in which the traffic after dark is considerable in volume.*

(2) *Important suburban roads in the vicinity of large towns.*

(3) *Rural roads.*

and having regard to modern conditions of traffic it is essential that adequate lighting by means of fixed lights should be provided in classes 1 *and* 2.

2. *As a general principle in the lighting of all Highways which require to be lighted by means of fixed lights the method of lighting to be adopted should be such as will provide an illumination as uniform and free from glare as possible. The amount of illumination and the position of lamps must be determined with reference to local circumstances.*

3. *It would be impracticable to light Rural roads generally by similar methods to those adopted in Urban streets or Suburban roads, and the lighting of vehicles using rural roads at night is therefore of the highest importance.*

4. (1) *All vehicles whether standing or moving on the road should be compelled by law to carry suitable lights in front and in rear or lighted lanterns, so constructed and fixed that the beams shall as far as practicable be visible both from the front and the rear.*

(2) *Every motor car must carry, after nightfall, two lighted lamps in front, and one at the back; if it is able to move at a high speed it must also be fitted in front with a headlight of sufficient illuminating power to light up the road or path for a least* 50 *yards to the front. In inhabited places where the ordinary lighting is sufficient to allow motorists to see their way and to be easily seen the light of the headlight must be limited to that of the ordinary lamp.*

5. (1) *It is desirable that all obstacles across a road such as gates and particularly gates at railway level crossings should be painted white and should be clearly lighted at night by means of fixed lights, preferably of a red colour, to indicate danger.*

(2) *It is desirable to paint white or indicate by some other method all danger signals, posts, direction posts and other posts, milestones, wheel kerbs, bridge abutments, etc., or other special features, the indication of which would aid travellers, or conduce to safety.*

6. *Red should be universally adopted as the colour for danger signals.*

Reports dealing with Public Lighting.

One of the chief features of the Congress was the presentation by delegates from different countries dealing with highway and vehicle lighting.

Mr. J. S. Brodie, Borough Engineer of Blackpool, in his report on the lighting of highways, remarks that there is no statutory duty placed upon highway authorities to light roads in their charge; still, practically all local authorities undertake this work and in fact, lighting is coming to be classed with the general upkeep and maintenance of roads.

A remarkable advance in the standard of road lighting has been made so that it is now considered practicable to draw up a specification specifying the minimum illumination required by different classes of streets. Mr. A. P. Trotter among others has done much work in this direction.

The chief object to be considered in street lighting are (*a*) the sufficient and (so far as practicable) uniform lighting of the pavements and roadway; (*b*) absence of glare in the eyes; (*c*) uniform colour in the illuminant. In practice it is difficult to secure exact compliance with the last two conditions.

In addition to the increase in the power of illuminants, considerable improvements in the automatic extinguishing and lighting up of lamps have been made. On the average the lighting and extinguishing of street lamps cannot be done efficiently by hand at a less cost than about twelve to fifteen shillings per lamp per annum. Recently, however, the use of automatic control of gas lamps by pressure waves and other devices has become usual.

At the conclusion of this paper the author presents some tables, derived mainly from the Board of Trade returns, showing the average cost per mile of street lighting per annum in various towns in the United Kingdom.

Road Lighting in the United States.

Quite a number of speakers testified to the excellence of British roads and the care now given to their upkeep.

Dr. C. H. Sharp remarks that in the United States the surface and lighting of the roads were until recently very defective. This was a natural result of the fact that the highways were made out largely under pioneer conditions. Another important factor has been the relative sparseness of population and the great distance involved.

Dr. Sharp gives a general survey of the illuminants suitable for street lighting making special reference to the constant current high voltage series system of lighting, the pressure occasionally being carried out as high as 10,000 or 15,000 volts. This method can be used in conjunction with arc lamps (a rectifier being generally necessary), and it has also been employed very efficiently with low voltage tungsten lamps. Curves showing the light distribution from electric arc lamps and incandescent lamps are given, and something is said as to the design of ornamental lamp-posts.

In discussing the principles of street lighting Dr. Sharp points out the important part played by the nature of the road surface—*e.g.*, whether it is wet or dry, rough or shiny. When the streets are wet objects appear silhouetted against the reflected light from distant lamps. It is chiefly the rays at small angles to the horizontal that cause glare. On the other hand Dr. Sharp thinks it is questionable whether absolutely uniform illumination is desirable. It is usually better to concentrate the light on important areas such as the intersections of streets.

Lighting of the National Roads in France.

Two reports presented by Messieurs E. Tur and E. Chaix, dealing respectively with the lighting of highways and vehicles in France, were of special interest. It is pointed out how remarkably not only the nature but also *the object* of street illumination has changed during the last few years. At one time public lighting was requisite chiefly as a measure of safety, but to-day the amount of illumination strictly necessary from the police standpoint has already been exceeded in many main thoroughfares. This increase in illumination has been rendered necessary mainly by the constant acceleration of the speed of vehicles. "A profusion of light is one of the best means of avoiding the occurrence of accidents on roads where numbers of fast moving cars are constantly crossing or overhauling each other."

A matter of great interest to the motorist is the lighting of the important cross-country thoroughfares of France. In country districts the lighting even of main roads is often primitive, and it may fairly be claimed that a larger proportion of the cost of upkeep should be devoted to illumination.

Over a length of 38,230 kilometres of national roadways in France, the total cost of maintenance of which amounts to thirty-two million francs, the total expenditure on lighting is not more than six thousand francs per annum—an exceedingly small percentage of the total upkeep. For roads in the country petroleum lamps are still used in the majority of cases, but are being replaced by acetylene lamps, which give a more powerful light. For main roads the use of electric lighting has been greatly stimulated by the development of water power; as a result many of the smallest villages are quite well illuminated. It may be said, however, that the lighting is very mixed, almost every method invented during the last 150 years being in use in some part of the country.

It is also hoped that in the future many of the great roads of France will be more completely illuminated than before. Perhaps it may be possible to have a general scheme of lighting in the case of main roads, instead of leaving the illumination to the judgment of the parishes through which it happens to pass.

The lighting of the public streets in Paris is carried out mainly with gas. During the last few years the chief feature has been the equipment of a number of the busiest thoroughfares with clusters of high pressure mantles.

Developments in Vienna, Brussels, Dresden, and St. Petersburg.

A series of papers by Leo Stransky, J. Hansez, G. Fleck, and H. Merczyng describe the conditions in the above cities. Mr. Leo Stransky points out the disadvantages of arranging lamps only at the sides of wide streets. This system is apt to leave the centre of the road insufficiently illuminated. He expresses the hope that in the future all the high roads will be illuminated even in the open and in the parts most remote from cities.

Mr. J. Hansez reports that road lighting in Belgium has vastly improved during recent years. This is due mainly to the wider application of electric light which is now met with even in the smallest villages. Clear globes with arc lamps have proved dazzling to the drivers of automobiles, and are considered less effective than those made of diffusing glass. Incandescent electric lamps in clusters are being now much used for street lighting. The author considers that roads in open country should not be illuminated, but lighting should be provided at level crossings, swing bridges, and all obstacles, &c.

Mr. G. Fleck (Dresden) comments on the spread of the method of suspending of gas and electric lamps over the centre of the roadway. It is remarked that in Germany most towns extinguish the greater part of the lights at 11 p.m., but on Sundays and feast days they are often kept burning ten hours later.

An important point made by Mr. H. Merczyng (St. Petersburg) is that in many districts there are special traffic requirements owing to the nature of the local industries, and special illumination is therefore needed. For example, in Lombardy, and probably in the immediate neighbourhood of many large towns, the volume of traffic is sometimes so enormous that it would be impossible to deal with the whole of it in the daytime.

Modern Motor Car Lighting.

Mr. G. W. Watson pointed out the remarkable advance in the lighting of vehicles that followed the development of the motor car. Pioneers in the motoring industry suffered considerable inconvenience because lamp manufacturers had not enough experience of the new form of locomotion to enable them to design suitable methods of illumination, but nowadays a number of ingenious and greatly improved methods are available.

The lighting of motor vehicles should serve the dual process of enabling the traveller to see far enough for safety and comfort, and of giving other people warning of the presence of the car on the road. Mr. Watson finds that present-day head lights suffice to show the road clearly for quite one hundred yards ahead, and even give light enough to throw shadows at a

distance of a quarter of a mile. He advocates that the head lights should be fixed on some part of the front axle so that the beams of light will always be projected in the direction in which the car is travelling. The candle power of a head lamp, according to the tests carried out by the Royal Automobile Club, in 1909, should be from 15—25 c.p., this light being focused and directed by suitable systems of lenses and mirrors.

The remaining part of this paper is devoted to a description of some electric and acetylene systems of lighting. As an example of the cost of apparatus and acetylene systems the author takes the case of a fleet of taxicabs, each of which has two side lamps, one tail lamp and a fourth one to light up the dial of the taximeter. The running cost of lighting such a cab is approximately one shilling per working week, or about 0·05d. per vehicle mile. On the other hand, the expense for acetylene lighting of a big company like the London General Omnibus Co. would be about 0·09d. per omnibus mile, the cost for each omnibus being about 5s. per week. Acetylene would appear to be slightly more economical than the paraffin lamps, and the light yielded is of course considerably greater.

The author also points out a curious effect of the increasing use of tar spray on our roads. A few years ago practically all roads had a light surface, and gave the effect at night of a white ribbon between dark borders. This helped the driver to keep to the road, and enabled him to distinguish dark objects on the road a long distance ahead. Nowadays the tarred surface used is comparatively dark, so that head lights of considerably greater power are needed to distinguish such objects.

Illuminated Signs on the Roadway.

According to the regulation of 1852 all vehicles in France, except agricultural carts, must carry a light, but their object is merely to call attention to the position of the movable obstruction consisting of the said vehicle ; it is only at the option of the owner if they are sufficiently powerful to enable the driver to see the state of the roadway in front of him.

The paper by Mons. E. Chaix contains a summary of the regulations at present in force dealing with the lighting of motor cars, horse drawn vehicles, bicycles and motor cycles.

Mr. Hansez (Brussels) refers to similar regulations in Belgium, and also suggests that drivers of cattle along the roadway after sunset should carry a lantern, to indicate their presence to the motorist.

Similar regulations for vehicles exist in Germany, but Mr. Fleck (Dresden) reports that motor cars and motor cycles must now carry a light capable of illuminating the road for a distance of 20 meters.

A development of interest to motorists in France has been the use of luminous signposts on the road. Illuminated devices are also used to denote the Custom House barriers at the entrance to a town. The Custom House authorities are arranging for the installation of similar barriers carrying lights at the frontiers where smugglers have learnt to ply their trade by the use of high speed motor cars. Level crossings are usually indicated by either one or two lanterns, petroleum or colza oil lamps being generally used. M. Tur recommends that in future all level crossings through which vehicles pass constantly should be illuminated, and that more powerful lamps should be used in the case of those that are much used by motor cars. He also suggests the erection of barriers with a square plate of iron painted white, showing the height of the obstacle.

There is also room for the more general use of illuminated signs at points in the road where special obstacles, cross roads, sharp turns, bridges or steep hills, &c., occur. But any such system of lights should be subjected to careful inspection, as the occasional extinction of the signals might have serious consequences. The use of white paint to indicate obstructions is also excellent, especially in countries where the sky is rarely clouded. For example, in Algeria all obstructions on the roadways are painted white, and besides being visible by the light of the stars, are very readily distinguishable by the searchlights of a motor car.

The Eastern Railway Co. has also adopted a method of attaching ruby coloured lenses 5 centimetres in diameter on barriers at level crossings. These lenses focus the beams of motor cars,

forming bright red points of light. It has been suggested, however, that such objects might be mistaken by the drivers of trains for railway signals, and that therefore some other colour instead of the red should be used.

Mr. L. Stransky (Vienna) regards the marking of all obstructions, whether temporary or permanent, as a most important feature, and should be settled by international agreement. He recommends the use of yellow lights for this purpose so as to avoid confusion with the signals of railway companies. Such caution signals should be placed 200 metres in advance of the obstruction so as to give the motorist time to pull up. Like other speakers, he advocates painting all obstructions (poles, trestles, &c.) used in road repair a white colour. There should also be an appropriate signal to indicate when a road is closed for repairs. As regards the lighting of vehicles, he urges that every vehicle making use of a public highway should carry at least two white lights, so arranged as to indicate the width of the vehicle. There should also be a tail lamp with a blue glass.

A NOVEL SUGGESTION FOR STREET PHOTOMETRY.

The question of the best method of measuring illumination in the streets has been much discussed. It is generally admitted that to measure in a vertical plane is hardly practicable for general purposes, since the result obtained would depend so greatly on what particular plane is selected. The horizontal plane has the unique advantage of automatically adding up the illumination from all the lamps in the neighbourhood; whereas a vertical plane might be illuminated by some lamps and not by others. On the other hand it has sometimes been contended that what we chiefly need in street lighting is a good vertical illumination, *e.g.*, enough light to read notices, to distinguish the sides of vehicles, and to recognise the faces of acquaintances.

It has sometimes been urged that if one could contrive some form of "integrating screen," taking account of the illumination in a number of planes, we should get a better result still—or at least a result which approached still more closely to the practically illuminating effect at the point studied. Something of this kind has been suggested by Mr. A. H. Ford in a recent paper before the American Illuminating Engineering Society. Instead of a flat screen, he has tried using a translucent block of paraffin wax, and also a small hemisphere composed of alba glass, which is viewed through a surface brightness photometer. The brightness of such a hemisphere, he points out, would depend *both* on the vertical and horizontal illumination. With the translucent glass hemisphere for example the fact of some light being transmitted into the interior should tend towards an even brightness all over, and thus approaching automatically an average value. On the other hand, Dr. Sharp, in discussing this paper, pointed out that the readings obtained with a translucent hemisphere of this kind would depend on the material used and would be of a distinctly "arbitrary" character.

Measurements in a horizontal plane may not be ideal, but they do at least represent a definite physical quantity.

Mr. Ford's suggestion is an interesting one, and seems to deserve investigation. Curiously enough, a very similar method is suggested by a correspondent in this number (see p. 471); in this case, however, an estimate of the brightness of a solid white sphere, about the size of a tennis-ball, was recommended.

STREET LIGHTING.

(A Report presented at the Convention of the National Electric Light Association held at Chicago, June 2nd—6th, 1913.)

The development of the many types of street illuminants and the development of the art of street illumination have been so rapid as to introduce a number of complex elements into the problem of street lighting contracts. Contractual clauses which, when accepted, were fair to all parties concerned and which would have resulted in satisfactory fulfilment of all terms of the contract under previously existing conditions, have proven unsatisfactory and have sometimes led to controversy and even to litigation due to the introduction of new illuminants and of new conditions. So general is the recognition of this fact, and so numerous have been the questions raised between municipalities and central-station companies, that not only in this country, but also abroad, there has arisen a strong demand for some authoritative and generally acceptable pronouncement which may be adopted in street lighting specifications in order to make clear and definite the fundamental basis of the contract while conserving with fairness the interests of both parties to the contract, and providing for an equitable distribution of the benefits accruing from progress in the art.

In considering the problem of street-lighting contracts, your Committee has had occasion to review the developments of recent years and has concluded that it would be of interest and value to incorporate such a review in its report. Accordingly, the present report is divided into three parts as follows :—

1. Brief review of the history of street lighting specifications.
2. Brief discussion of the various measures of illuminating power of street lamps which have been proposed from time to time.
3. Recommendations of the Committee regarding contractual basis for street lighting.

Historical Sketch.

Early attempts at photometry quite naturally took the form of measurements of light intensity in some single direction. Illuminants which antedated electric lamps were rated, if at all, in terms of unidirectional light intensity. Those interested in the manufacture and supply of such illuminants naturally sought for rating purposes the angle and direction in which highest intensity could be realised. The construction of early forms of photometers tended to standardise the horizontal plane of illuminants for photometric purposes. Photometry prior to the advent of commercial forms of electric lamps was largely restricted to tests of the candle-power of illuminating gas and in the gas industry candle-power normal to the plane of the flame—which is to say maximum candle-power—had become standardised.

When commercial rating of incandescent electric lamps was first undertaken, it became the accepted standard practice to make the measurements in a direction which would yield an approximation of the mean horizontal candle-power. It will be seen, therefore, that from the very beginning the electric lighting industry voluntarily placed itself at some disadvantage as compared with its rival by adopting as a standard of measurement the mean horizontal candle-power of the illuminant, instead of the maximum candle-power.

In early attempts to determine the candle-power of arc lamps it became the established practice that ratings should be based upon determinations of maximum candle-power in a particular direction. In the determinations of such candle-power values experimenters had to deal with a new form of illuminant of much higher power than any before employed and with unsteady light differing in colour from prevalent light sources to an extent not before experienced in commercial lighting practice. It was but natural under such circumstances that there should be a wide diversity of experimental results and that those interested in the commercial success of the arc lamp conformed to the prevailing practice in adopting the higher maximum

candle-power values rather than the lower average values in referring to the illuminating power of the arc lamp.

The early "2,000 candle-power" value having been derived through crystallization of opinion based upon the photometric experiments of several observers found its way into certain street lighting contracts and became established in the art in a way which led to numerous well-known difficulties in later years when other electrical illuminants became available. At the present time the best available information as to the *average* candle-power values of the 9·6 ampère series direct-current open arc lamp consuming 450 watts at the arc is as follows:—

Mean spherical candle-power, 375 to 450.

Corresponding total light flux, 4,714 to 5,656 lumens.

Maximum intensity, about 45 deg. below horizontal, 900 to 1,200 cp.

It is believed that these average values are typical of substantially the same type of lamp which was known in the earlier years as the nominal 2,000 candle-power arc lamp. Attention is called to the fact that these as stated are *average* values. It is true that individual maximum values have been obtained which reach under favourable conditions values as high as 2,000 candle-power.

In 1894 the National Electric Light Association, upon the recommendation of a committee on rating of arc lamps, adopted the following resolution:—

"Recognising the difficulty, if not impossibility of measuring with any degree of accuracy the illuminating power of the arc lamp, and the great necessity for a more precise definition and statement of the obligations of the producer of electricity for illuminating purposes to the consumer thereof, be it

"Resolved, That in the opinion of this convention what is ordinarily known as a 2,000 candle-power arc lamp is one requiring on the average 450 watts for its maintenance, the measurements being made at the lamp terminals, where no sensible resistance is included in series with the arc."

This resolution was of value in defining the direct-current 9·6 ampère "full arc" and constituted a fair and easily verified specification as far as that type of lamp was concerned.

Later the development of other types of arc lamps having different qualities created a demand for some more comprehensive and flexible specification to serve as a basis of contract. This need has been felt keenly during the past few years and a number of attempts have been made to meet it. Prominent efforts in this direction may be briefly summed up as follows:—

In 1906 the Photometric Committees of the Verband Deutscher Elektrotechniker and of the Vereinigung der Elektrizitats-Werke reported certain proposals for the rating of arc lamps. These were revised in 1907 and adopted. The basis of rating is the mean lower hemispherical intensity with clear globes, this being accompanied by the coefficient by which such value must be multiplied to obtain the mean spherical intensity.

A further standardization rule promulgated by the Verband Deutscher Elektrotechniker approves for study of street illumination the determination of the mean horizontal illumination intensity one meter above the street level, this being accompanied by statements of the maximum and minimum intensities in order to indicate the uniformity.

In 1906–1907 the National Electric Light Association appointed a "Committee to Consider Specifications for Street Lighting." At the 1907 convention this Committee submitted a well-considered discussion of the problem of street lighting with special reference to its contractual phases and advanced the view that some measure of the illuminating value of street lamps should be adopted in street lighting specifications and suggested for use in arc lighting specifications, the mean normal illumination produced by a particular lamp in the street at the height of the observer's eye and at a distance of not less than 200 and not more than 300 feet from a point immediately below the lamp.

At the annual convention in 1908 the relative rating of several types of arc lamps on the basis indicated in the report of the 1907 Committee was reported by Mr. Ryan on behalf of the Committee. No data for other street illuminants were adduced. The practical effect of the specifications recommended by the 1907–1908 Committee was a rating of lamps in terms of light intensity in one direction at an angle approximating ten degrees below the horizontal. However, the recommendation has not been adopted extensively in street lighting contracts so that it is impracticable to report upon its merits as a solution of the general problem. With the advance in the study of the problem of street lighting which has been made since 1908, it appears to have become generally felt, in this country, that such specification does not offer the best solution of the problem and that some other more promising basis must be developed.

As a result of discussion of street lighting of the Institution of Electrical Engineers in London in 1910, a committee was appointed to draft standard clauses for inclusion in a specification for street lighting. This was a joint committee composed of representatives

of the Institution of Electrical Engineers, the Institution of Gas Engineers, the Institution of Municipal and County Engineers and the Illuminating Engineering Society. This Committee has prepared a report recommending certain clauses for street specifications which were embodied in a paper presented by Mr. A. P. Trotter before a meeting of the Illuminating Engineering Society in London on April 15th, 1913. The purpose of this presentation was to afford an opportunity for discussion of the proposals and the paper elicited so much discussion that an adjourned session on April 29th was necessary. These tentative proposals recommend as a basis of street lighting contracts the determination of minimum horizontal illumination 3 ft. 3 in. above the ground for all street lighting in which the minimum is at least 0·01 foot-candle. In street lighting having lower minima, the contract basis is to be the candle-power measured in the direction of the thoroughfare at an angle 10 degrees below the horizontal plane of the illuminant.

Such, in brief, is the recent history of the street lighting contract problem. The need for the establishment of acceptable specifications is felt more generally than ever before and no one of the specifications which has been proposed appears to meet with general acceptance.

Measures of Illuminating Power which have been Proposed.

The street lighting problem combines important commercial considerations with a number of very interesting technical problems. In consequence much attention has been given in recent years to the solution of the problem, and the literature is replete with discussions of the subject. Among these may be found expressed the views of central-station company representatives, both electric and gas, the views of municipal engineers, of photometrists and of illuminating engineers. The more prominently favoured proposals of measures of street illumination are reviewed briefly below in order to present to the member companies a compendium of the subject.

Measures of Street Lamps and Street Lighting—Including Both Those Which Have Been Adopted in Certain Instances and Others Which Have Been Proposed from Time to Time.

Measures based upon tests of lamps.

1. *Unidirectional Light Intensity.*

Instances—2000-cp. for "full arc" in direction of maximum intensity, as generally accepted in early years of arc lighting.

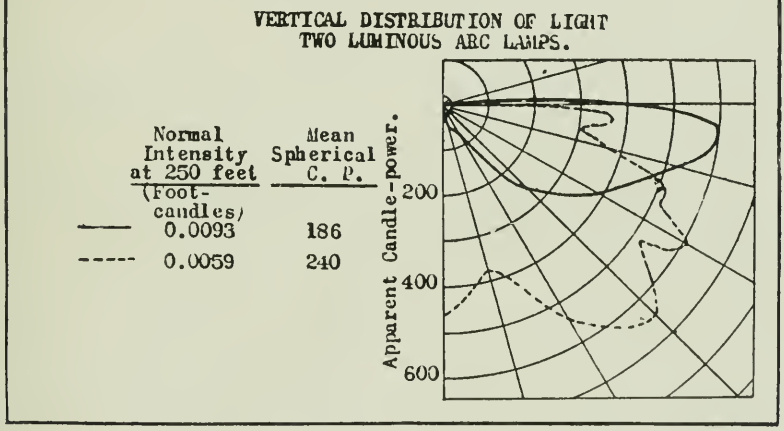


Fig. 1.—Showing the inequality of a system of "unidirectional" rating of street lamps.

Normal illumination intensity 200 to 300 feet from the lamp, as proposed by 1907–8 N. E. L. A. Street Lighting Committee.

Such ratings are likely to be found objectionable in that they conduce to the advantage of some particular illuminant and to the disadvantage of illuminants whose light distribution characteristics are less favourably adapted to high rating in the particular direction chosen. There is no one direction which may be counted upon to afford a reliable indication of the illuminating power of all illuminants.

A rating based upon light intensity in a particular direction is liable to mislead because of minor irregularities in the equipment of illuminants. For example, the old open arc lamp presented a light source of extremely small area. Imperfections in the clear glass

globes which were employed in standard practice resulted in marked striations of alternately high and low light intensities. In a unidirectional rating, such as that referred to in the second instance, the resultant evaluation of a particular lamp might vary from 25 to 200 per cent. of the average value, being dependent upon the accidental location of the photometer in either a bright or a dim area.

As a second example of the objectionable nature of a unidirectional rating, Fig. 1 is presented. This shows curves of vertical light distribution about two early forms of luminous arc lamps. The distribution of the one is such as to secure a very favourable rating under the 1907–8 N. E. L. A. rules which deal exclusively with light delivered a few degrees below the horizontal. The second lamp (of a type long since abandoned) was equipped with a clear glass globe of improper design whose curvature led to strong refraction of the light in the critical direction. In consequence, the second lamp, though giving considerably more light than the first, was rated as of only slightly more than half the illuminating power.

A 4-ampère luminous arc lamp gives six or seven times as much total light as a 50-cp. incandescent lamp. To cite a third example, Sharp* has designed a reflector for street lighting which under the rating procedure just referred to would enable a 50-cp. incandescent lamp to receive a rating of 25 per cent. higher than a 4-ampère luminous arc lamp.

Thus it appears that any unidirectional rating is inadvisable because: (1) it does not afford a satisfactory comparison of illuminants whose natural light distribution characteristics differ; because (2) it is liable to undue influence in consequence of equipment irregularity; and because (3) it points the way to manipulation of the light with a view to re-enforcement in that particular direction, irrespective of the illuminating effect elsewhere.

2. *Rating by Light Intensity in a Particular Plane.*

Instance—Mean horizontal candle-power which is the general basis of rating for incandescent lamps.

At the present time the rating of incandescent lamps in terms of mean horizontal candle-power is a source of constant difficulty to lamp engineers. In ignoring the intensities in other directions, difficulties are encountered in standardizing lamp efficiencies and filament temperatures whenever alterations in the construction or new types of lamps are introduced. This form of rating has left the way open to serious misunderstandings growing out of changes in shape of lamp filaments in order to alter the light distribution and serve some particular purpose. In the incandescent lamp industry this difficulty has become generally recognised and all lamp ratings in mean horizontal candle-power are now accompanied by corresponding relative values of total light flux. Ratings by intensity in a particular plane are open in a lesser degree to most objections urged against ratings by intensity in a particular direction.

3. *Rating by Mean Intensity Throughout a Particular Zone.*

Instance—Recommendation of Photometric Committee of Verband Deutscher Electrotechniker for rating of arc lamps in terms of mean lower hemispherical intensity, with reference factor to yield mean spherical intensity.

Such ratings are preferable to those described above, but leave considerable to be desired in that they too are open, though in a lesser degree, to redirection of light into the stipulated zone, more with a view to securing a high rating than with a view to securing the most acceptable form of light distribution. Manufacturers of illuminants which distribute light largely within the lower hemisphere, for example, are inclined to favour a lower hemispherical candle-power rating. For many kinds of street lighting such a rating has much to recommend it. The action in Germany adopting this basis of rating for street illuminants was well considered, but it is gratifying to note that a reduction factor by which to obtain the mean spherical candle-power was stipulated, thereby safeguarding a mean lower hemispherical rating.

4. *Watts.*

Instances—Recommendation of 1894 Committee of National Electric Light Association.

Practice of American and English incandescent lamp manufacturers in rating incandescent electric lamps.

The wattage rating for arc lamps was adopted in 1894 in order to identify a particular type of lamp. It served its purpose well, but was only a means to an end and not a real basis of rating illuminants. A rating based on watts alone is not likely to be proposed in the future, though as one of a number of items specified, it is not to be neglected. In the incandescent lamp field the rating by watts serves the purpose chiefly of identifying a given size of lamp and does not purport to be an ultimate rating except as a means to the end of indicating the candle-power which in contemporary rating corresponds with the stated watts.

5. *Miscellaneous.*

Instance—Abady, *Electrical Engineer*, June 16th, 1910; Edgecomb, *Electrician*, June 20th, 1913. Mean of candle-power intensities respectively 20 and 50 degrees below the horizontal, this being taken to afford a fair approximation of the mean lower hemispherical candle-power.

This appears to be an attempt to rate lamps in terms of mean lower hemispherical candle-power by employing street tests to approximate that value.

Measures based on tests of illumination.

In general, these measures vary with respect to: (a) Height above ground at

* I. E. S. Trans. Vol. v, page 375, 1910.

which determination is made ; (b) inclination of illuminated surface during test ; (c) aspect relied upon as a criterion ; that is, average intensity, minimum intensity, etc.

Such measurements generally deal with the total light which impinges upon the test surface irrespective of its source. Usually such a value is the sum of the light received directly from a number of lamps, plus light reflected from surrounding objects.

6. *Normal Illumination at Heights Varying from 3 to 6 feet Above Street Level.*

In such measurements the test surface is variously inclined in order to make its plane at all times perpendicular to the direct light from the nearest illuminant in one direction. If such test surface is screened from all other light, the measurement yields the candle-power of the lamp when the illumination intensity is multiplied by the square of the distance. Normal illumination intensities are usually higher as to numerical average than either horizontal or vertical illumination intensities. The basis for such a measure is found usually in the consideration that objects on the street are brightest when viewed by light which is incident perpendicular to their surface, and that the normal illumination is therefore the best indication of the illuminating value. The method is sometimes endorsed because the values midway between lamps are higher than those encountered in measurement of horizontal illumination and are therefore less liable to photometric inaccuracy.

7. *Vertical Illumination.*

Considerations underlying vertical illumination as a measure of street lighting effectiveness appear to be that most objects viewed in the street present more or less vertical surfaces.

8. *Illumination on Surface Inclined at Angle of 45 Degrees.**

Such measurement appears to be a sort of a compromise between the vertical and the horizontal.

9. *Horizontal Illumination.*

INSTANCES—Standard method recommended by the Verband Deutscher Elektrotechniker.

Tentative recommendation of joint committee in England.

The horizontal illumination appears to be more generally favoured than any other measure. It shows the combined illuminating effect of lamps in both directions, which no other measure accomplishes. It leads to a determination of the total flux of light upon the street which is a valuable quantity in gauging street illumination. Small illuminants mounted low appear least favourably when rated upon this basis and the advocates of such illuminants therefore are usually opposed to this method.

Irrespective of the inclination of the photometric surface in tests of street illumination, there is a large variation in the choice of values to serve for rating purposes. The *average* intensity throughout the street is regarded by many as the most desirable quantity—others prefer the *minimum* intensity, arguing that if the minimum is high enough, the street lighting is satisfactory. Still others feel that the average intensity associated in some way with the *uniformity* of the lighting should be the basis of judgment. Without venturing an opinion at this time as to the most desirable general basis of illumination study, it may be said that the minimum intensity is regarded as undesirable, being open to many of the objections urged against a unidirectional form of rating, and not affording a fair measure of the value of the street lighting service.

This brief review of the history of street lighting specifications and of proposed measures of lamps and illumination presents the problem of street lighting specifications in all its complexity. Among its principal features will be noted an official pronouncement in Germany and tentative recommendations now under discussion in England. These two bases differ radically, and it will be seen later that both differ from the recommendations which your Committee has to make. Furthermore, the Committee reports in Germany and in England do not, by any means, represent unanimous conclusions in those countries. The printed record contains considerable objections to the Committee reports on the part of engineers in each country.

It is evident that one reason why no acceptable solution of the problem has been found is the great uncertainty which exists in regard to the fundamental nature of the problem. The basic principles of street illumination have not been thoroughly established. Such diversity of opinion could hardly exist in regard to measures of street illumination if the quantity to be measured were established beyond peradventure.

* Harrison—Proceedings of Institution of Electrical Engineers, Dec. 12, 1905.

The simple fact is that to-day study of street illumination has not proceeded far enough to enable even the most expert consideration to formulate a correct measure or standard of its effectiveness. In the opinion of your Committee, the time is not ripe for an attempt to establish a standard specification for street lighting in which some simple and direct measure of street lighting effectiveness may be embodied.

Before it will become practicable to draft street lighting specifications based upon illuminating effect, extensive investigation of street lighting will probably have to be carried out. It remains to be determined what, if any, measure of street illumination may be applied to all systems of street lighting in a way to indicate the relative illuminating effectiveness of each system and to show systems of different kinds to have equal illuminating value when similar streets lighted by the respective equivalent systems are equally well illuminated.

The review suggests a further consideration which your Committee urges upon your attention as being a fundamentally important step toward eliminating much of the existing confusion. It is that *the best means of studying street illumination and arriving at the relative illuminating value of two different installations is not necessarily the best method of specifying the street lighting service which the street lighting contractor undertakes to give and the municipality agrees to purchase.* At this point there must be a fundamental division of consideration. We have here two separate and distinct problems. In the first, that of deciding among several different systems of lighting and arriving at the best arrangement of the system selected, the purpose of street lighting must be considered, the fundamental principles of street illumination must be studied and an effort must be made to gauge the extent to which these are accomplished. Consideration must be given to such questions as height, spacing, power of lamps and globes or reflectors. The surroundings and character of the street must be considered, and it is important to know the illuminating intensity, maximum, minimum and average, the uniformity, the amount of glare, the colour of light, &c.

In the second problem, that of providing a means of proving fulfilment of contractual obligations, it is necessary to consider only the simplest and most reliable means of determining if the contractor is giving the stipulated and specified service. It would be desirable in some respects to have the same tests serve both purposes, but there is no necessary connection or relation between the two. For purposes of contract specifications, two steps are necessary.

(1) Specify and describe lamps beyond chance of misunderstanding and describe in detail operating practice.

(2) Prescribe and provide means of establishing the fact that the lighting equipment and that the operating practice are those agreed upon.

It will be clear that many of the difficulties which have been encountered in endeavouring to arrive at a suitable basis for standard street-lighting specifications are the outgrowth of the view that the test of street illumination which most accurately measures the illuminating value of the service is the test which should be applied in order to prove actual fulfilment of contract specifications. Your Committee draws especial attention to this aspect of the problem, regarding the removal of this impression as a matter of first importance.

RECOMMENDATIONS OF COMMITTEE.

Conditions have not permitted your Committee to undertake during the past year the needed investigations of street illumination preparatory to recommending street lighting specifications covering the study of street illumination, the comparison of different systems as to effectiveness and the many other interesting and practical problems which need to be solved in order to contribute to the best development of the street lighting art. Your Committee has, however, deliberated upon the other more immediate and pressing question of proposing a reliable and simple basis for street lighting contracts which shall be definite, free from ambiguity, sufficiently comprehensive to include all types of street

illuminants, and sufficiently flexible to facilitate the substitution of newer, superior illuminants when available as alternatives in place of those specified in the contract.

Referring in general to those proposals which involve photometry in the street, under actual operating conditions, it is the judgment of your Committee that they should not be recommended at this time. Conditions for photometry are naturally much less favourable in the street than in a well-equipped testing laboratory. Portable photometric apparatus is usually of a lower precision than high-grade laboratory apparatus. The relative inexpensiveness of portable testing apparatus, which makes it generally available, enables even the inexperienced to make photometric measurements of a character to give general results or approximations. Only the most expert methods, however, can produce accurate results on which to predicate and decide upon the fulfilment of contractual obligations. Therefore, while emphasising the importance of portable photometric apparatus used under careful restrictions by competent photometrists for the determination of the illumination produced and a study of its intensity and distribution with a view to selecting the best system and securing the most favourable location and equipment of illuminants, it has been deemed wise to recommend as a basis for determining upon compliance with contract requirements only laboratory tests, where better assurance can be given of approved apparatus and methods, and of expert photometry. The only exception which, in the opinion of your Committee, should be made to this recommendation, is in the case of such illuminants as cannot be removed from the street to a suitable laboratory and there operated in such a manner as to reproduce with substantial accuracy the actual service operating conditions.

The Committee recommends the following procedure in drafting street lighting contracts. Assuming that decision has been reached as to the type of illuminant which it is proposed to use :

(1) Describe the lamp which is proposed, including in the description electrical values (volts, ampères and watts) and total light flux (lumens) or mean spherical candle-power, employing well-authenticated conservative values representative of the performance of the lamps under the conditions of service contemplated.

(2) Describe the equipment to be supplied with the lamps, including type of globe, reflector, if any, &c.

(3) Specify reasonable average limits to be allowed above and below the representative values of light flux given in the description to allow for inherent variables and test inaccuracies which are beyond the control of the contracting company.

(4) Provide for basis of substitution of other types of illuminants for those specified, either lamps of equivalent illuminating value having other characteristics, or lamps of different illuminating values, in order to provide for progress in the art during the term of the contract.

(5) Prescribe the method of test of the circuit while in actual operation to determine the conditions of current supply as found under actual operating conditions on the system.

(6) Prescribe procedure for proving fulfilment of contract in respect to illuminating qualities of lamps, including therein the selection for testing in a properly equipped testing laboratory and under the operating conditions as found, of a reasonable number of lamps taken from the system and a test procedure which will assure expert methods, approved apparatus and fair evaluation of the lamps.

The following clauses of description are submitted as properly exemplifying the principles here emphasised :

Type and Rating of Lamps.

The lamps to be furnished shall be of standard type, operating at not less than ..... volts at the lamp terminals, consuming not less than ..... ampères and not less than ..... watts at the lamp terminals, or not less than ..... watts at the arc, provided with electrodes giving in this lamp with the

above current and power consumption, and with clear glass globes, not less than ..... total lumens or not less than ..... mean spherical candle-power, or lamps of a type mutually acceptable to the two parties to this contract, and giving at least equal total light flux or equal mean spherical candle-power.

Auxiliaries for Lamps.

The lamps as installed shall be equipped with.....
(Light directing or diffusing auxiliaries.)
the average light absorption of which, when clean and in good condition, shall not exceed ..... per cent. of the total light flux.

It is hoped that a succeeding committee of this Association may undertake the preparation of data for various street illuminants which may be embodied by member companies in street lighting contracts, and that in the course of its investigations undertaken with this object in view, it may be successful in outlining a test procedure which this Association may approve and recommend in all cases where it is undertaken to prove fulfilment of street lighting contracts.

It would indeed be a useful and valuable contribution if a succeeding committee would undertake to draft a model standard form of contract and specifications which would be clear and definite in their terms, and yet sufficiently flexible to meet the varying conditions to which they would be applied, and which would receive the official endorsement of this Association. It is felt that such a standard contract form, carrying with it the endorsement of this Association, would go far toward eliminating the frequent contentions as to the meaning and interpretation of the loose phraseology which is so common in the current forms of street lighting contracts. These contracts involve the most important relations of the lighting company to the municipality which it serves and from which it derives its franchise, and it is of the utmost importance that the relations of the company to the general public be not jeopardized by a loosely drawn street lighting contract, which may, through misinterpretation of its provisions, place the company in a false and unjust position before the public.

Respectfully submitted,

Committee { J. W. Lieb, Jr., *Chairman*
Louis Bell
Albert F. Ganz
Preston S. Millar
C. P. Steinmetz

AERIAL LIGHTHOUSES.

The news that a powerful electric lantern, with a range of over fifteen miles, is to be placed on an observation tower at Biberach to serve as a beacon for airships travelling northward from Friedrichshafen is an indication of the fact that night voyages by aircraft are becoming practicable in the Fatherland.

Aeronauts will be keen to know the design of the new beacon tower, for opinions are much divided as to the most efficient. Seen from far above, it has been proved that the blaze of a beacon fire is easily confused with accidental fires. In the case of a lighthouse, it is clear, some easily recognisable peculiarity must be devised.

Aeronauts over the coast at night have no difficulty in picking up their bearings from the intermittent lights placed there for mariners. These can be read by the chart.

Already we may be near the time foretold by Mr. Kipling in "With the Night Mail," a wonderful picture of an aerial world illuminated from below by coloured beams of light.—*The Pall Mall Gazette.*

CORRESPONDENCE.

THE REQUIREMENTS OF STREET LIGHTING.

Dear Sir,

I have been greatly interested in the discussion on the Street Lighting Specification in recent numbers of the ILLUMINATING ENGINEER. It seems to me that many of the speakers were involuntarily confusing two things—hence the fierce fight for direct ray measurements. Street lighting really consists of two parts, pavement lighting and roadway lighting, and to the man in the street the former is the more important.

Now pavement lighting is chiefly necessary in order to enable one to recognise friends and acquaintances, rather than for the purpose of seeing the pavement, which will always be kept in good repair in any town that can afford respectable lighting. For the purpose in view a high vertical illumination at the face level (say, 5½ ft. from the ground) is what is required.

Now, since no person possesses a flat face, why not measure the illumination on a hemispherical test surface of, say, 3 in. in diameter, using a surface brightness photometer adjusted to take in the whole of the surface, and automatically average its brightness (I find that the Holophane lumeter held horizontally does this pretty well with a tennis ball).

Lights at a height of 12 ft. are almost invariably trying on the ground of glare. In fact, from this standpoint there is much to be said for the old days when every householder was compelled to place a candle outside his house. The lights being subdivided into small units would be much less glaring. At the Papal Jubilee in the South of Ireland we had a very good demonstration of this fact. About 6—10 candles (real candles) were placed in the windows of each cottage, the windows facing immediately on to the pavement and at a height of 3—4 ft. above it. The candles being well set back in the windows were only visible at quite close range and caused little glare. Both the pavement and the passers-by were surprisingly well illuminated.

In the case of roadway lighting the conditions are entirely different. One is not so much concerned with the clearness of near objects, but is constantly looking "a certain time ahead"—the time depending on the control exercised over the motor, horse or cycle. Naturally the distance one looks ahead varies with the speed of travelling. The cyclist looks further than a person walking would do, and to him absence of glare is a very important factor. I once had the misfortune, when cycling, to run into two old ladies, simply on account of the glare from a lamp some distance ahead. This was placed on a post 12 ft. above the ground. The roadway was very black, due to the constant passage of coal carts, and the ladies were also dressed in black and standing well in the middle of the road. In spite of the fact that I had a good acetylene lamp on the bicycle, I rode into the two without seeing them simply because of that street lamp falling immediately within the field of view. On these grounds, would it not be desirable to arrange that in roadway lighting the limiting ray should strike the ground a little over halfway between the lamps, *all rays higher than this being cut off by an opaque reflector?*

In really well-lighted first class streets, where the roadway is presumably always kept in good repair, a high illumination of the roadway is not so vital. The existence of any repairs or digging operations is made evident by special local signal lamps, and vertical illumination at a height of about 5 ft. should be considered, in the manner suggested for pavement lighting.

In country districts only the footpath need be seriously considered, and absence of glare is the chief requirement. Vehicles all carry their own lights. It seems to me, therefore, that in any form of specification some attempt should be made to distinguish between these different conditions. Still, I recognise that there must be compromise, and anything tending to specify the light in precise terms, the light provided should be for the public benefit.

I am, yours, etc.,

A CORRESPONDENT FROM IRELAND.

ILLUMINATING ENGINEERING IN JAPAN.

What is to be the future of illuminating engineering in Japan?

A valued correspondent, Dr. Oya of the Electrotechnical Laboratory at Tokyo, sends us some photographs illustrating the application of the old style Japanese lanterns to electric lighting. Electric lighting is making great strides in the East. We see there, existing side by side, modern electric fittings (often, alas! more efficient than decorative) and the old paper lanterns and candles that have served the Japanese as illuminants for so long. A glance at a booklet issued by a company in Tokyo, shows that while some European innovations are being introduced piecemeal, others are being moulded more in accordance with Oriental traditions, the shape and style of the shades being distinctly different from those common in Europe.

We should not be surprised if Japan, in matters of illumination, pursued a line of her own. We understand that the high intrinsic brilliancy of unshaded modern illuminants does not commend itself to a people accustomed to the mellow effects of lamps screened in paper lanterns, and the comparatively subdued light characteristic of artificial illumination in the East. Probably, therefore, absence of glare will be a strong feature in Eastern illumination. Full use will be made of the decorative possibilities of silk and coloured paper, in which the Japanese are consummate artists.

As an illustration of what can be done in this way, Dr. Oya sends us two photographs of lanterns, many of which were fitted with electric light and used on the occasion of the Imperial funeral of the late Emperor of Japan. These are made of obscured glass fitted into a plain wooden frame with gold decorations, and their appearance when illuminated is said to have been very fine.

SOME STATISTICS OF THE LIGHTING INDUSTRY.

In *Licht und Lampe* (Febuary 27th, 1913) a striking collection of statistics bearing on the lighting industry throughout the world was recently given. Few people realise the immense amount of capital locked up in enterprises directly connected with illumination by gas, electricity, petroleum, &c., and the following table, abstracted from this journal, may be instructive :—

Table I. (showing output of gas, electricity and petroleum in the chief European countries and the United States).

		Germany.	Austria-Hungary.	England.	France.	Spain.	Russia.	Sweden.	U.S.A.
Gas.	No. of stations	500	70	250	820	74	110	—	400
	Annual output in cubic metres (milliards) ..	1·1	0·2	3·0	0·6	0·1	0·3	—	2·9
	Price per cubic metre (Pfgs.)	10—18	16—20	4—12	15—32	25—40	18—30	—	8—17
Electricity.	No. of stations	2800	800	500	1000	40	40	82	5000
	Annual output in k.w.-hrs. (milliards) ..	0·5	0·2	0·2	0·3	0·03	0·03	0·09	2
	Price per k.w.-hr. (Pfennigs)	30—60	30—50	30—40	30—40	40—60	40—60	25—40	30—40
Petroleum.	Total consumption in kilos. (milliards)	0·9	(production) 38	0·4	—	—	(production) 98	—	(production) 87
	Price per kilo. (Pfennigs) ..	25	—	—	—	—	—	—	—
Annual output of light (Hefner-hrs.) (milliards)		1700	400	3200	900	—	—	—	5800
Population (millns.)		65	49	45	39	19	162	5·5	101
Annual output of light per head of population (very approx.)		26	8	70	23	—	—	—	58

According to this table more light per head of population is used in England than in any other country for which the statistics are complete. Doubtless a different result would be obtained by comparing great industrial cities.

An immense amount of money is spent each year in generation (gas and electric supply stations, &c.). But it must be remembered that huge sums are also locked up in lighting appliances. It is reckoned that of the gas produced in Germany 7—12 per cent. is used in street lighting and 30—35 per cent. for interior lighting. This corresponds to a yearly output of about one thousand milliard candle-power hours. In the same way the electric lighting annual output is about 250 milliard candle-power hours ; six per cent. of the total electricity generated being used for arc lamps and 27 per cent. for glow lamps. In the streets above 250,000 arc lamps are used, and for indoor lighting quite twenty million glow lamps.

It will be seen, therefore, how vast and far-reaching is the effect of even a small improvement in lighting appliances.

The following tables show roughly the distribution of capital in the lighting industry of Germany :—

TABLE II. Capital invested in Light Production in Germany.

1. 45 per cent. of capital invested in gas works	330,000,000	Mks.
2. 33 per cent. of capital invested in electric lighting works ..	330,000,000	,,
3. Transport and storage of petroleum	100,000,000	,,
4. Burners, lanterns, and lighting appliances for gas	200,000,000	,,
5. Electric glow lamps, arc lamps, fixtures, &c.	250,000,000	,,
6. Petroleum lamps, &c.	90,000,000	,,
	1300,000,000	,,

TABLE III. Money spent annually in the Maintenance of Illumination.

1. Consumption of gas (reckoned at 13 pf. per cub. metre) ..	150,000,000	Mks.
2. Replacing mantles, globes, &c.	20,000,000	,,
3. Consumption of electricity (at 40 pf. per k.w.-hr.)	200,000,000	,,
4. Replacing of glow lamps, maintenance of arc lamps, &c. ..	42,000,000	,,
5. Cost of petroleum, spirit and benzol (at 25 pf. per litre) ..	250,000,000	,,
6. In wicks, chimneys, &c., for oil lamps	10,000,000	,,
7. New installations	50,000,000	,,
	750,000,000	Mks.

THE NATIONAL GAS EXHIBITION.

The National Gas Exhibition is to be opened on Monday, October 1st, by the Lord Mayor of London, and it is also announced that the patronage of their Majesties the King and Queen, and of other members of the Royal Family has been accorded.

An interesting series of papers has been arranged, and quite a number of these deal with lighting. Among these we note :—

THE SCHOOL OF THE FUTURE: its Lighting, Heating and Ventilation, by S. Warwick, F.R.I.B.A., and A. Hall, F.R.I.B.A.

SOME CONSIDERATIONS ON THE APPARENT BRIGHTNESS OF LIGHTS, by Professor Silvanus P. Thompson (President of the Illuminating Engineering Society).

THE HYGIENE OF GAS FOR LIGHTING, by Dr. S. Rideal.

LIGHT AND SIGHT, by Dr. Meredith Young.

THE ECONOMY OF EFFICIENT LIGHTING, by Franklin Thorp.

THE AIMS AND OBJECTS OF THE ILLUMINATING ENGINEERING SOCIETY, by Leon Gaster.

THE LIGHTING, HEATING AND VENTILATION OF FACTORIES AND WORKSHOPS, by Professor Vivian Lewes.

THE ECONOMIC VALUE OF ADEQUATE ILLUMINATION, by Leon Gaster.

There will also be a series of popular lectures during the exhibition, and a collection of photographs illustrating lighting installations of various kinds is being made.

Another item is the exhibition of a series of old lamps and objects of historic value, many of them lent by the City of London.

We also understand that the planning of the exhibits themselves will be of a novel kind, and altogether the exhibition promises to be one of exceptional interest.

A PETROL AIR GAS INSTALLATION.

It will be remembered that in the paper on petrol air gas, read before the Illuminating Engineering Society by Mr. E. Scott Snell last January, an account was given of an interesting country house installation in Essex. The two photographs show views of the hall and dining room in this house, and are taken entirely by artificial light. They illustrate the shaded subdued illumination still preferred by many people for domestic lighting.

In the dining room the wall lights are covered by silk shades fringed with beads, while in the hall the burner is completely enclosed in a square silk-lined lantern. The effect of this stairlight is decidedly ornamental, and the soft effect apparently enables the eye to manage with quite a low order of illumination.

Hall lighted by silk lantern equipped with petrol air gas burner.

LIGHT—THE SOUL OF ART.

This was the title of a popular lecture recently delivered by Mr. M. Luckiesh in the United States, in the course of which he showed one distinctly telling experiment.

Two identical pictures representing a mountain scene were illuminated respectively by orange-red and white light. In the latter case, the glowing peaks of the distant mountains were clearly seen; with the orange-red light they entirely disappeared. By gradually changing the colour of the light from orange-red to white the mountains could be made to gradually "grow up" on the picture.

This illustrated very clearly the fact that the appearance of any coloured object depends on the spectrum of the light by which it is illuminated.

Dining room lighted by silk-shaded petrol air gas burner.

SOME NOTES ON THE LIGHTING OF PICTURE PALACES.

By An Engineering Correspondent.

In the last number of *The Illuminating Engineer* there was a short article on the lighting of cinematograph theatres. It was mentioned that in the United States there are reported to be no less than 20,000 such theatres, and the number in the United Kingdom must also be very considerable.

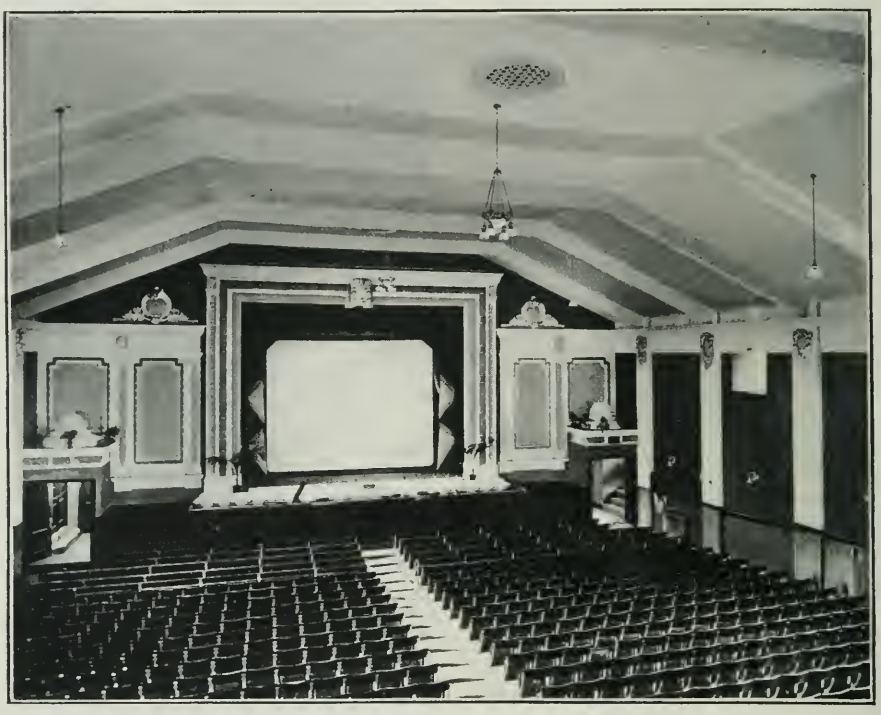


Fig. 1.—Showing Lighting of the Scala Theatre, Newcastle, lighted by tungsten lamps and Holophane reflectors.

The cinematograph brings with it quite a number of problems for the illuminating engineer. There is, first, the design of the projector lamp and the screen. On these points a great deal of ingenuity has already been expended, but there is still a vast field for improvement. Secondly, there is the lighting of the theatre itself, which offers quite a number of interest. In this article it is proposed to confine attention to the illumination of the "auditorium" (a singularly inappropriate name still used for picture palaces, notwithstanding the fact that the impressions are received through the eye and not through the ear).

The illumination conditions are broadly similar to those in an ordinary theatre. The screen on which the images are received, like the stage in the theatre, should be the chief point of interest. The general lighting is, therefore, in general turned down while the performance is in progress. But owing to the

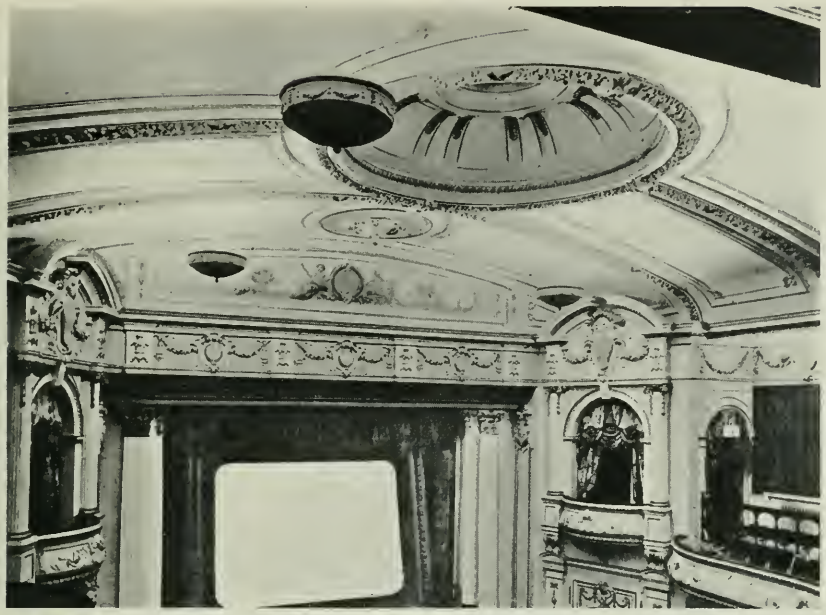


FIG 2.—Night View of Auditorium of the Lime Street Picture Palace, Liverpool, lighted by indirect means. (B.T.H. "Eye-Rest" System.)

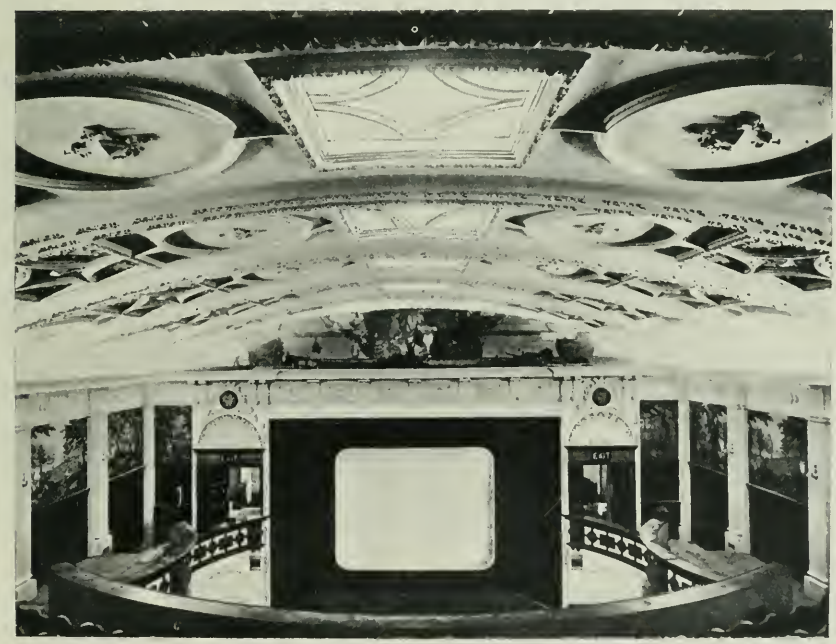


FIG. 3.—Night View of Cinema House, Sheffield, lighted by Mazdalite Lamps in B.T.H. Trough Reflectors concealed in the cornice, and by six domes, illuminated with X-ray Reflectors, the light being subsequently diffused through amber-tinted glass.

fact that people are constantly entering the room cannot be left in total darkness, and a small amount of illumination should always be allowed.

It need scarcely be said that in lighting a cinematograph theatre the fittings are placed high up out of the range of sight, or as brackets on the walls, and precautions should be taken to avoid anything in the nature of glare. According to a paper by Mr. F. G. Martin in the Transactions of the Illuminating Engineering Society last April, the average brightness of the cinematograph screen in America is about 0·4 foot-candles; in this country the average would be very similar—possibly somewhat higher. The general illumination provided on the seats in the theatre is stated to lie between 0·2 and 1 foot-candle, the higher value being usually at the back, where people are constantly entering. This again seems to be very similar to the conditions in this country.

The first illustration shows the method of lighting in the Scala Theatre at Newcastle, the photograph and information relating thereto being supplied by Messrs. Siemens Bros. Dynamo Works, Ltd. The lighting is done by Wotan lamps and Holophane reflectors. The main ceiling fixtures each consist of a central Holophane sphere surrounded by four "Household" reflectors. There are three such electroliers; spaced equidistant round them there are six Holophane stiletto reflectors containing 100-watt lamps. At the stage end there are also two 3-light cluster fittings using "Household" Holophane glassware. On the front of the circle there are five 2-light brackets and twelve single-light brackets illuminate the side and end walls of the Pit and Stalls. Fifty 32-c.p. lamps are used in the brackets, in addition to the 100-watt lamps used in the pendants previously mentioned. The total floor area illuminated is about 3,600 sq. ft.

In view of the recent vogue in indirect and semi-direct methods of lighting for cinema theatres, it is probable that the Holophane semi-indirect fitting very recently put upon the market would prove still more acceptable for this class of work.

Figures 2 and 3 are reproduced from two photographs of cinematograph theatres lighted by the British Thomson-Houston Co., Ltd., who have furnished the following information. In the picture palace at Lime Street, Liverpool, the auditorium is lighted by four 36-in. "eye-rest" fittings. The two units over the balcony each contain 200-watt lamps in X-ray reflectors; each of the other two contains four similar lamps. There are also three small fittings under the cornice on each side, each containing one 100-watt lamp.

The back part of the balcony is lighted by three 24-in. fittings, each containing four 100-watt lamps. There are three 21-in. fittings, each containing five 60-watt lamps, and four 18-in. fittings, each containing three 60-in. lamps, under the balcony. All these fittings are of moulded composition with Adams's decoration. The four large fittings round the dome are hung on a special contact and suspension gear concealed in the ceiling, so that they can be lowered to the floor for cleaning, lamp renewals, &c. It may be added that the floor area in this theatre is 4,300 sq. ft., and the corresponding area lighted in the gallery 2,600 sq. ft. In such theatres, the writer is informed, the company usually provide an illumination of about 1 foot-candle.

The application of indirect lighting to cinematograph theatres is interesting. The fact that the sources of light are invisible in these circumstances is stated to enable the pictures to be shown successfully with the lamps still on. For example, at the Lime Street picture house it is the practice to switch out the lamps in the four large fittings entirely but merely to reduce the illumination in the small fittings by means of a suitable dimmer. The illumination is brought down to an intensity which does not interfere with the clearness of the pictures and enables visitors to find their places and read their programmes in comfort.

In Fig. 3 an entirely different system of lighting has been used, the illumination being provided by special trough reflectors concealed in the cornices.

The reflected surface is so designed as to throw a beam of light right across the ceiling to the opposite side, illuminating it evenly all over. A similar method is employed in the balcony. The total consumption of the lamps so used is,

FIG. 4.—General View of the lighting of the West End Cinema (Coventry Street, London). The main illumination is derived from the central dome, decorated in blue and gold and illuminated by concealed lights, and from the ring of amber-coloured lamps behind diffusing glass discs surrounding it. Attention may also be drawn to the lighting of the panels by concealed lights. The ceiling dome and ring are separately controlled.

approximately, 4,900 watts. The tapestry panels round the walls of the auditorium are also illuminated by specially designed trough reflectors and Mazda lamps.

The floor area in this theatre is, approximately, 2,400 sq. ft., and that of the balcony 1,600 sq. ft.

An interesting feature of this installation is the dome lighting employed in this auditorium. There are six domes in this ceiling, and these are covered on the under side by amber-tinted glass. In each dome, above this amber glass, are fitted six 60-watt lamps in X-ray reflectors, upturned so as to throw their light on the white dome. The light is reflected downwards from the inner surface of the dome, and is diffused through the amber glass. The effect of this illumination is said to be very fine.

This system of "dome lighting" seems to be finding favour for the lighting of cinematograph theatres, an excellent illustration being provided by the West End Theatre in Coventry Street, London, where permission was kindly granted for some photographs to be taken. Fig. 4 shows a general view of this theatre taken from the gallery, and Fig. 5 is a photograph of the ceiling. The main lighting is provided by the central dome, which is illuminated by twelve completely concealed 25-watt lamps, and by a ring of 48 lamps above amber-coloured discs surrounding it. The dome ceiling is decorated in gilt and blue, giving something of the effect of a blue sky, and its brightness is about 8 foot-candles.

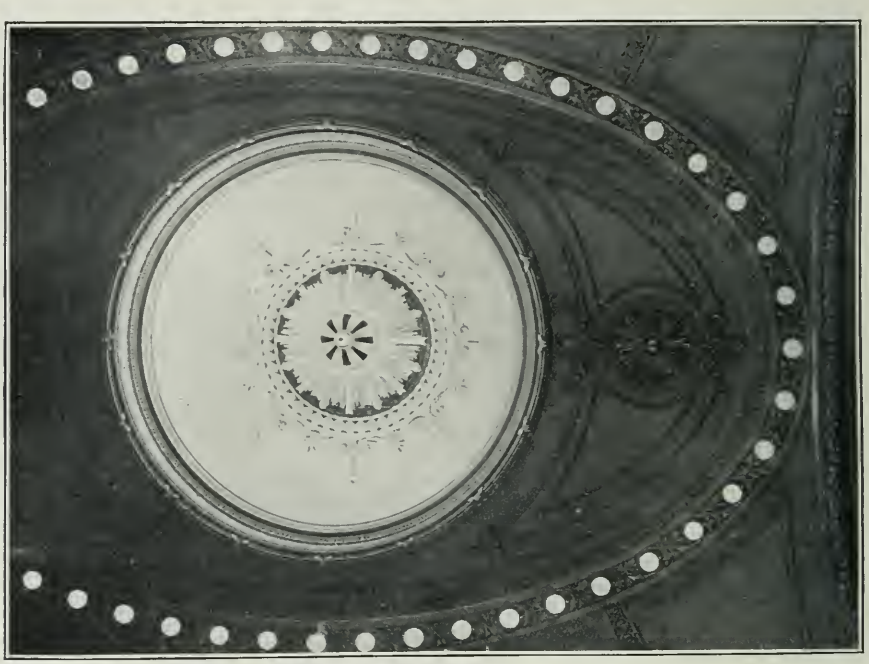


Fig. 5.—Photograph of illuminated dome in the ceiling of the West End Cinema (Coventry Street, London, W.), taken from below.

Twenty-five candle-power lamps are used throughout this installation, most of them being amber dipped. There are five concealed lights above the panels on each side of the theatre, and four 3-light brackets, each consisting of two diffusing orange globes and one red globe. The general effect is very soft, and the main tint of the illumination is a mellow orange. It may be suggested that the use of colour for the general lighting of the auditorium has a certain value, since it leads the spectators involuntarily to

draw a distinction between this and the picture on the screen. Possibly this in itself would enable some of the lights to be turned on while the pictures are being shown without interfering with their clearness.

The general effect in this theatre is decidedly good. The various items in the lighting are separately controlled, and the sky can be turned on without the ring of amber lights or *vice versa*. In this theatre the illumination in the gallery is slightly under 1 foot-candle. For the floor the illumination in the front is about 1·1 foot-candles. The value at the back under the gallery is about 0·3. As is usual, the exits are illuminated in red, the lights being kept on permanently.

One other point that deserves special mention in cinematograph theatre lighting is the method of dimming the lights. The effect of constantly switching on the lights in the auditorium after the eye has become used to the darkness, is apt to give rise to a distinct shock. It is, therefore, becoming customary to control the lights by a dimmer enabling them to be lighted up gradually. It is desirable that the grading of the steps in the dimmer should be gradual and uniform; if the resistance on the last stop is too great the increase in light as the handle is finally moved over may be too sudden. The same fault may occur if the operator is careless in the use of the dimmer and moves the handle too quickly.

There are, of course, other points in connection with cinematograph theatre lighting on which much might be written. For example, there is considerable scope for ingenuity in the design of attractive methods of lighting outside the theatre. At the West End cinema referred to above, an interesting installation of the Moore light in the form of an arch, supplemented by the name of the theatre in the form of a Neon tube (presumably the first erected in London), is to be seen. It is hoped shortly to give some account of this exterior lighting.

TRADE NOTES.

[At the request of many of our readers we have extended the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

THE HALF-WATT PER CANDLE LAMP.

Messrs. Siemens Bros. Dynamo Works, Ltd. (Tyssen Street, Dalston), in announcing that half-watt lamps will be available commercially during the present year, wish to make it clear, however, that for some time to come the new lamps will only be supplied in units of high candle-power, such as are mainly suitable for illuminating large areas, and for outdoor lighting.

THE "VERICO" DAYLIGHT LAMP.

An interesting Siemens novelty is the "Verico" lamp, which is merely an ordinary Wotan lamp with a special tinted globe, giving an approximation to daylight. It is to be noted that this lamp is stated to be relatively efficient, consuming on an average only about 1·5 watts per candle.

B.T.H. HALF-WATT PER CANDLE LAMPS.

As we go to press, comes the announcement that the **British Thomson-Houston Co. Ltd.** are introducing a half-watt per candle lamp, developed in the research laboratory of the G.E.C. of America. The first lamps available will range from 100-1500 c.p., and higher intensities still will be available shortly. A life of over 1,000 hours is anticipated.

We have had an opportunity of seeing several of these lamps,—stated to be giving 1300-1400 c.p. and to be manufactured at Rugby,—in operation at Mazda House.

The spiral drawn wire tungsten filament is very stout and is wound in a simple loop. The bulb is stated to be filled with an inert gas, such as nitrogen, and this has an important influence in making the improved efficiency possible.

The brilliant white light yielded by the new lamps will doubtless render the use of modern forms of shades and reflectors still more essential, and is favourable to the use of semi-indirect illumination.

AN INTERESTING SHOWROOM.

In our last number we referred to some of the new fittings in the showroom of **Messrs. Sugg & Co.** (67, Regency Street, London, S.W.). The full-page illustration on the opposite page is from a photograph taken entirely by artificial light, and shows a variety of these fixtures.

Around the room will be seen quite a number of interesting units. In the foreground one of the little ornamental semi-indirect marbled glass fittings is shown lighted. In the far corner, one of the ventilating ceiling lights recently described in these columns is also lighted up, and a number of semi-indirect fittings are on view in the background.

This firm makes a speciality of fittings for school lighting. For this work, as is well known, absence of glare is an important factor, and in most of the Sugg units the mantle is surrounded by a lightly frosted globe. The frosting, however, is confined to that portion of the globe liable to cause glare and is so distributed as to screen the mantle completely in directions from which it is likely to be viewed in an ordinary class room. There is also a suitable opal shade above the mantle, and this, acting as a bright background, serves both to reduce glare and to concentrate the light downwards.

THE IMPROVED "UKAY" LAMP.

The chief feature of the improved UKAY lamp introduced by **Messrs. Falk, Stadelmann & Co.** (Farringdon Road, London, E.C.) is the simplicity and accessibility of the parts. The lamp can be readily dismantled by merely unscrewing the lock nut at the top, when the cover lifts off, exposing the entire interior to view. But no iron is used in any parts except casing. The pipes, burners, hinge and bolts are brass, and the central chimney conducting away the products of combustion is of aluminium, which does not corrode or "flake," and does not induce condensation. It should, therefore, be only rarely that the interior needs attention.

But what is perhaps the most distinctive feature is the fact that not only the adjusting needle but the entire gas injector can be removed *en bloc* for cleaning purposes. The gas injector and the air injector are conveniently placed side by side, and the latter is of special design.

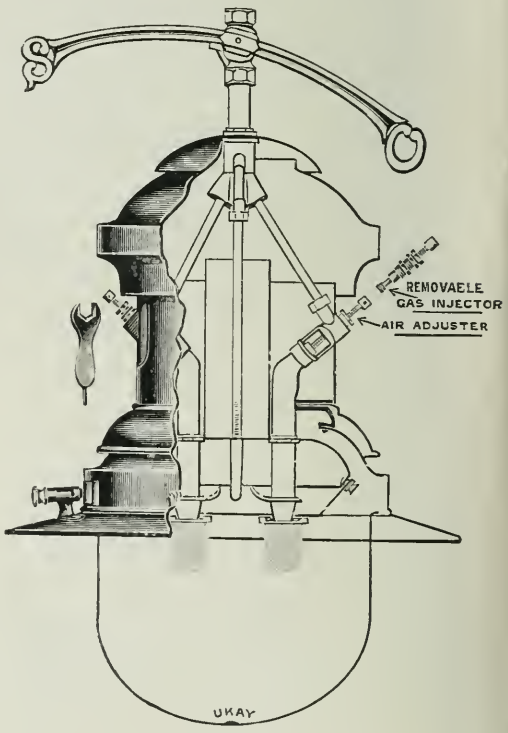
The UKAY lamp is stated to give 125 candle-power (mean hemispherical) per burner, consuming 4 cub. ft. per hour, on ordinary pressures. Three burners, giving about 400 candle-power in all, are generally used, but we understand that models of this lamp giving up to 1,000 candle-power will shortly be available.

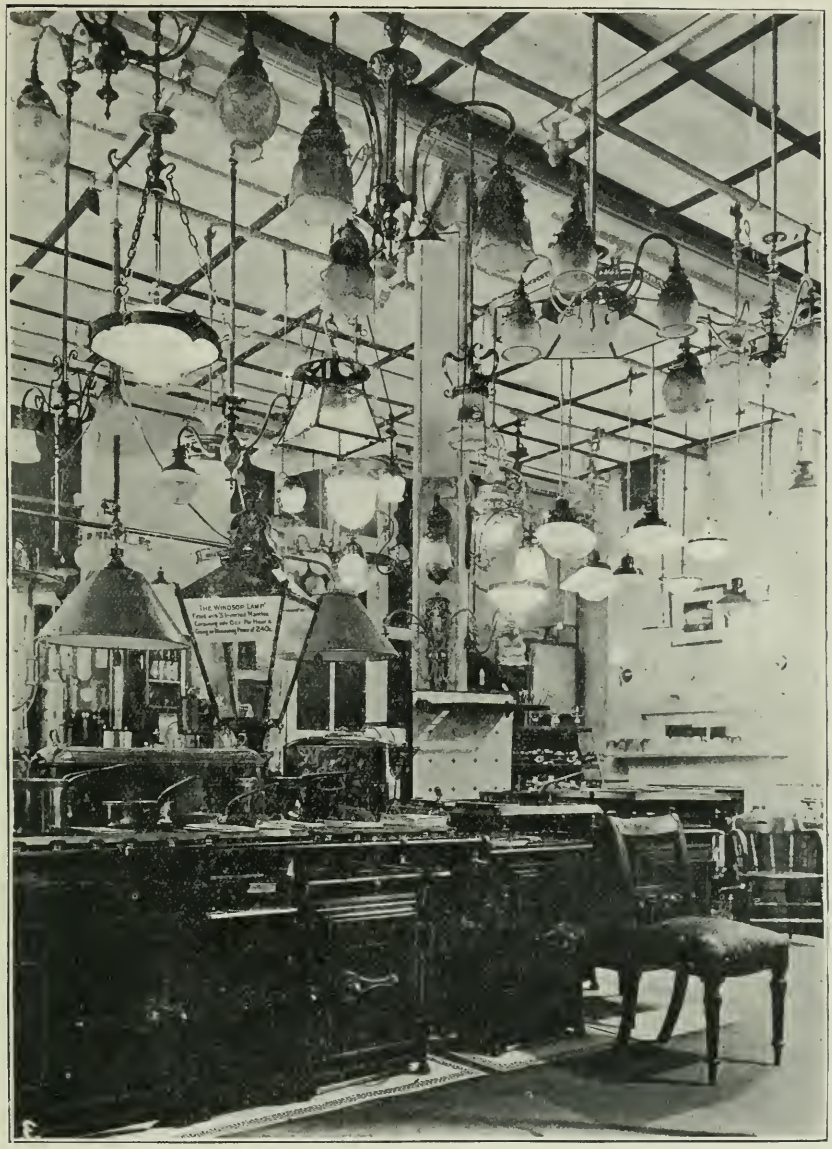
ELECTRIC LIGHT FITTINGS.

The new catalogues of electric light fittings and accessories issued by Messrs. **Falk, Stadelmann & Co.** (83—87, Farringdon Road, London, E.C.) contain, as usual, illustrations of a great variety of fixtures, the Holophane reflectors, bowls and spheres, and the various systems of direct and semi-indirect lighting being well represented.

In addition to the ordinary household fittings, we notice that a speciality is made of decorative artificial candles and lanterns in the French style, statuettes and cut-glass crystal chandeliers. Another striking section is that devoted to church fittings. Mention should also be made of selection of silk shades and their use with portable table lamps.

The electrical fixtures catalogue (Edition No. 359) contains approximately 300 pages, and is concluded by a suitable index. The electric accessories list is just about half the size.





General View of Show Room of Messrs. W. Sugg & Co. (Regency Street, London, S.W.), from photograph taken entirely by artificial light.

"INVERTOLITE" FITTINGS.

Yet another form of semi-indirect fitting is that turned out by the **Wardle Engineering Co., Ltd.** (196, Deansgate, Manchester). This consists in a translucent bowl fitted under an enamelled white reflector, and it is recommended specially for the lighting of offices, schools and shops.

REVIEW OF THE TECHNICAL PRESS.

SEVERAL decidedly interesting items occur in the June number of the *Transactions* of the American Illuminating Engineering Society. H. E. IVES describes some ingenious experiments with novel home-made fixtures, for example, the use of unusually large paper surfaces as semi-indirect units, the placing of lamps outside windows to simulate the distribution of light from the sky, and **the imitation of daylight** by the aid of strongly illuminated specially shaped reflecting surfaces hung on the walls of the room.

R. F. PIERCE describes, with illustrations, a highly novel method of **lighting an exhibition hall** by means of pedestals carrying concealed clusters of upright gas mantles. T. W. ROLPH analyses the nature of the direction of light from metal reflectors, and gives some clear diagrams showing the difference between direct and diffused reflection and a mixture of the two.

L. C. PORTER AND K. W. MACKALL (*Elec. World*, July 19th) give the results of some **tests on headlights,** and criticise the law introduced in some American States requiring an intensity of 1,500 candle-power for motor vehicles. As far as the illumination of the road is concerned, such a regulation has little value, and they suggest the distance at which the test is to be made and the angle covered by the beam of light should also be stated.

There are also quite a number of articles discussing rather visionary prospective new illuminants. Recent articles in the *Zeitschrift für Beleuchtungswesen* describe some new patents relating to the use of rare earths to be brought to incandescence either by the direct passage of an air current, or by the heat of the arc. There is also an interesting account by BENKE of some current speculations as to the nature of the electron disturbances that give rise to luminescence.

Among contributions on photometry may be noted the experiments of H. C. STEVENS on the **Flicker photometer** (*Phil. Mag.*, July). Lord Rayleigh has suggested that the sensation of flicker is due to the action on the muscles controlling the iris diaphragm. But the author finds that when the action of the iris is paralysed by atropine the sensation is still experienced.

LIST OF REFERENCES:—

Illumination and Photometry.

Avenberg, A. L., and Fischel, R. E. Test of Indirect Lighting (*Elec. World*, July 5).

Berthelot, D. Les Mechanismes Biologiques et les Phenomènes Electriques (*Bull. Soc. Int. des Electriciens*).

Berke, A. Der heutige Stand unserer Kenntniss der Luminescenzerscheinungen (*Z. f. B.*, July 30).

Bordoni, U. Due diagrammi per il calcolo dell' illuminazione prodotta dalle superficie diffondenti (*Atti della Assoc. Elettrot. Ital.*, June 30).

Cobb, P. W. Vision as influenced by the brightness of surroundings (*T. I. E. S.*, June).

Editorials. The Lighting of Schools and Libraries (*J. G. L.*, July 15).
The Standardisation of Headlamps (*Elec. World*, July 19).

Howe, H. E. Chemical and Physical Properties of Optical Glass (*Optical Jr.*, July 17).

Ives, H. E. Some Home Experiments in Illumination from large area light sources (*T. I. E. S.*, June).

Myhill, R. A. The Jet Photometer as an Instrument for testing illuminating power (*J. G. L.*, July 8).

Pearson, A. L. Modern Methods of Lighting in Cotton Mills (*Industrial Engineering*, July).

Pierce, R. F. Artificial Daylight for Colour Matching (*Am. Gaslight Jr.*, August 4).

Porter, L. C., and Mackall, K. W. Fundamental Principles of Headlamp Illumination (*Elec. World*, July 19).

Rolph, T. W. Metal Reflectors for Industrial Lighting (*T. I. E. S.*, June).

Stevens, H. C. The Flicker Photometer (*Phil. Mag.*, July).
Deutsche Beleuchtungstechnische Gesellschaft (*J. f. G.*, July 12).

Voege, W. Die Strahlung unserer kunstlichen Lichtquellen im Vergleich zu einander und zum Tageslicht (*L. u. L.*, July 17).

INDEX, September, 1913.

	PAGE.
Editorial	447
Illuminating Engineering in Japan	473
Indirect Church Lighting	456
International Medical Congress, Notes on	451
International Road Congress, Notes on	453
Lighting Industry, Some Statistics of the	473
Office Lighting Installation, A Modern	453
Petrol Air Gas Installation, A	475
Picture Palaces, Notes on the Lighting of	477
Public Highways and Vehicles, Lighting of	453
Review of the Technical Press	484
Street Lighting, An Important Report on	463
Street Lighting (Correspondence)	471
Trade Notes	481

Electric Lighting.

Editorial. Free Tungsten Renewals (*Elec. World*, July 26).
Tungsten Lamps for Streetlighting (*Elec. World*, July 26).

Löwy, J. Die elektrische Automobilbeleuchtung (*Elek u. Masch.*, July 27).

Möller, G. Elektrische Lampe (*Z. f. B.*, July 20).

Silva, S. Un'esperienza sulle correnti alternate attraverso filamenti incandescenti (*Atti della Assoc. Elettrot. Ital.*, June 15).
Die sogenannte "Kalte Licht" (*Z. f. B.*, July 10).
Tests on High C.P. drawn wire lamps (*A. E. G. Zeitschr.*, June).
Die elektrische Dampflampe (*Z. f. B.*, August 10).

Gas, Oil, Acetylene Lighting.

Alberts, E. Wann ist die Einfuhrung von Pressgas oder Pressluft Beleuchtung zu empfehlen? (*J. f. B.*, July 26).

Berg, A. M. Photography by Artificial Light (*Am. Gaslight Jr.*, July 7).

Crain, G. D. An up-to-date campaign for Better Light (*Gas Age*, July 1).

Editorial. Incandescent Gas Light nearest to Daylight (*J. G. L.*, August 12).

Othmer, E. Gas und Elektricität im Lichte der Volkswirtschatt (*J. f. B.*, August 16).

Pierce, R. F. Gaslighting in an Exhibition Hall (*T.I.E.S.*, June).

Rosemberg, P. L'Éclairage des Eglises par l'Acétylène (*Rev. des Eclairages*, July 31).
l'Éclairage des Tramways à Vapeur (*Rev. des Eclairages*, July 31).
The Illumination of Railway Carriages with Acetylene (*Acetylene*, July 1).

CONTRACTIONS USED.

Elek. u. Masch.—*Elektrotechnik und Maschinenbau.*

E. T. Z.—*Elektrotechnische Zeitschrift.*

J. f. G.—*Journal für Gasbeleuchtung.*

L. u. L.—*Licht und Lampe.*

T. I. E. S.—*Transactions of the Illuminating Engineering Society* (*U.S.A.*)

Z. f. B.—*Zeitschrift für Beleuchtungswesen.*

THE

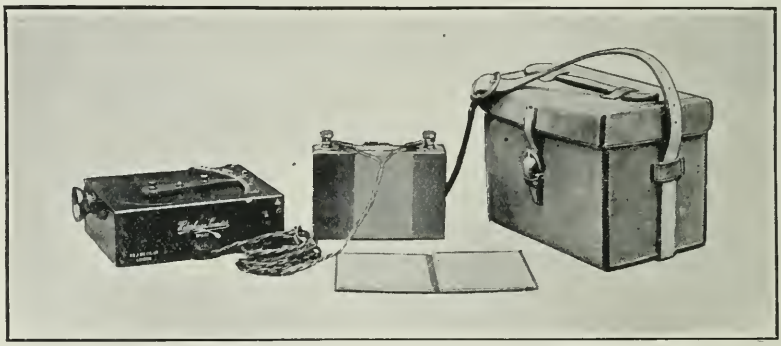
Holophane Lumeter.

THE simple, portable, and accurate apparatus for measuring illumination, surface-brightness, or reflecting power.

Can be carried from place to place with the ease of a small hand camera.

Dimensions only $5\frac{3}{4}$ in. × $4\frac{1}{2}$ in. × $1\frac{3}{4}$ in; case and accumulators supplied.

Measurements from 0·01 to 2000 foot-candles can be made.



Showing general appearance of new model of Holophane Lumeter.
(Dimensions : $5\frac{3}{4}$ in. × $4\frac{1}{2}$ in. × $1\frac{3}{4}$ in.)

The Holophane Lumeter is of value not only to lighting engineers, but to architects, medical officers, factory inspectors, photographers, and many others.

Among the users of this instrument may be mentioned :—

The House of Commons, The Home Office (Factory Dept.), The London County Council, General Post Office, Great Western Railway, L. & S.W. Railway, Underground Railways, The Gas Light & Coke Co., St. James and Pall Mall Electric Supply Co., The Union Electric Co., The British Thomson-Houston Co., &c., &c.

For all particulars apply to

HOLOPHANE, LTD.,

12, Carteret St., Queen Anne's Gate, S.W.

The ILLUMINATING ENGINEER
ELECTRICITY · ACETYLENE · OIL · GAS
Edited by LEON · GASTER

THE JOURNAL OF SCIENTIFIC
ILLUMINATION.
OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London, 1909.)
ILLUMINATING ENGINEERING PUBLISHING COMPANY, LTD.,
32. VICTORIA STREET, LONDON, S.W
Tel. No. 5215 Victoria.

EDITORIAL.

The International Commission on Illumination.

The formation of the International Commission on Illumination, to which we draw attention in this number (see pp. 491—494) must be considered a most important event in the history of illuminating engineering.

The need for such a commission, which was suggested by the writer in a paper presented at the International Electrotechnical Congress in Turin in 1911, is now generally admitted. There are many questions connected with the symbols and nomenclature of illuminating engineering which need to be referred to a competent and impartial international tribunal, and there are also some very important problems in industrial lighting which should come within its scope. It will be recalled that at Turin a resolution was passed by the Congress unanimously approving the formation of an international commission on illumination. Since that resolution was passed a scheme has happily been put forward of securing this result by enlarging the scope and representation of the Zürich International Photometric Commission. The new Commission has been successfully launched at Berlin on these lines, and we hope and believe that it will receive adequate support from all parties concerned with the subject.

Some doubt was originally expressed as to whether the Zürich International Photometric Commission, being a body appointed to act for the gas industry, could be modified to deal with all illuminants; it was feared that there might be a difficulty in securing the co-operation of the electrical industry in connection with the scheme. These obstacles have, to a great extent, been smoothed away by the work of the International Electrotechnical Commission during the last few years, and the formation of national electrotechnical committees in the various countries. In particular the resolution passed by the International Electrotechnical Commission at Turin in 1911, desiring the national committees to put themselves in touch with the illuminating engineering societies in their respective countries when dealing with matters connected with illumination, has led to a desire for *rapprochement* between the gas and electrical industries. Another important influence has been the development of the illuminating engineering societies in Europe and the United States, which have been the means of bringing representatives of the two illuminants in contact with one another, and suggesting opportunities for beneficial co-operation. But should any unforeseen difficulties be encountered, which we do not anticipate, it may be noted that the resolution taken by the International Electrotechnical Congress at Turin would provide for a second effort.

For the successful conversion and extension of the Zurich Commission, special thanks are due to the efforts of, amongst others, the President, M. Vautier, Dr. E. P. Hyde, and Mr. C. C. Paterson, who is now the Hon. Secretary of the new Commission. London thus becomes the official centre from which business will be transacted. It was recognised that London is well fitted geographically to act as a link between the Continent and the United States, and the advance of the illuminating engineering movement in this country has doubtless been appreciated by all who have followed the work done by our Society.

In the new statutes of the Commission provision has been made for the formation of National Committees in all the chief civilised countries. Where Illuminating Engineering Societies already exist, it was agreed these bodies might quite well be selected to replace the national committees and might appoint members to serve as delegates on the International Commission on Illumination. In order to provide for equal representation of the gas and electric interests it would also be desirable that the delegates appointed should also be members respectively of the Institutions of Gas and Electrical Engineers. This precedent was established by Germany at the Berlin Congress and might with advantage be followed in this and other countries. The Illuminating Engineering Society is well fitted to act in this way because it has among its members so many representatives of older and longer established bodies, and the Institutions of Gas and Electrical Engineers would naturally expect to be represented by those of its members who have made a special study of illumination. The existence of National Committees in all the chief countries should facilitate the authoritative investigation of many problems connected with industrial lighting and will

afford an exceptionally effective channel for bringing these matters before the general public. The lighting of schools, factories, and public buildings should come within their scope, and we hope that generous support will shortly be given for the carrying on of researches on this subject. The proceedings at the Congress of School Hygiene, to which reference is made below, aptly illustrate the need for investigations into school lighting. The movement for better lighting should receive special assistance in a country whose pride it has been to care for the health of all its people—from the child at school up to the aged worker in the factory. The matter is of national importance, and we venture to suggest that due encouragement might well be forthcoming from the Government of this country.—We may mention that the Government of another European nation has already provided a grant of £1,000 a year in order to facilitate the work of a similar Commission.—We feel sure that generosity in this respect will be repaid to the nation many times over in years to come.

The International Congress on School Hygiene.

Last month we were referring to the International Medical Congress held in London during August, and we pointed out the great value of such congresses as a means of disseminating information among the general public. At this Congress Dr. James Kerr and Mr. J. Herbert Parsons read papers on various aspects of illumination as affecting vision. These papers led to a keen discussion, and it is pleasing to see that the medical profession, in whose hands so much power rests to remedy the abuse of light, are taking these questions up with greater vigour.

We have now before us an account of the papers presented at the Fourth International Congress on School Hygiene held at Buffalo during August 20th to 30th. On this occasion Dr. James Kerr presented a paper on School Lighting, and summarised the conclusions of the British Joint Committee on the subject, of which he is Chairman. An enterprising step was taken by the American Illuminating Engineering Society in arranging for a joint conference on School Lighting, and we understand that the exchange of views between lighting engineers and medical authorities led to a very useful discussion. Joint meetings of this kind can do much to harmonise the views of experts, and the same method has been previously adopted by the Illuminating Engineering Society in this country with great success.

We would like to see artificial lighting taking a much more prominent place in school hygiene in the future. In some text-books on School Hygiene written by medical authorities the position of windows and daylight illumination are discussed in detail, but little reference is made to artificial light. We have no doubt that the good work being done by the Illuminating Engineering Society in England and America will bring about a needed change in this respect.

The connection between poor eyesight and defective conditions of illumination seems to be now well established. This is emphatically a case

in which prevention is better than cure. In this country, the authorities have recently embarked on an elaborate scheme of school inspection. We suppose that, in an average school, the expense of medical inspection per annum exceeds considerably that necessary to cover the cost involved of putting the lighting on a satisfactory basis. Moreover the benefit of improved lighting, once introduced, would be permanent, and prevention of defects of vision is surely preferable to their alleviation by means of glasses, &c. Medical officers themselves are doing their utmost to cope with the defective vision unfortunately so prevalent in the schools of to-day, and it is only right that the lighting should be up to a reasonably good standard in order that their efforts may have a fair prospect of success. This continuous depreciation in eyesight is obviously an industrial drain on the nation. It means that we are turning out people whose earning power and value to the community is impaired. Every effort should, therefore, be made to ascertain the causes of these defects and to secure their removal.

The National Gas Exhibition.

This number appears on the eve of the opening of the National Gas Exhibition at Shepherd's Bush.

We have several times laid stress on the efforts that are being made by the Executive Committee to render the Exhibition novel, attractive, and instructive to the general public. The feature that appeals most to us is the prominent place given to illumination, and we understand that there will be a number of exhibits of more than ordinary interest.

We have before us the programme of conferences to be held during the month. Special days are allotted to such subjects as the value of good illumination from the educational standpoint, the hygiene of lighting and heating, some aspects of scientific illumination, &c., and there will be a conference of manufacturers at which various papers dealing with industrial illumination are to be read.

The importance of the occasion will be understood from the list of presidents and vice-presidents of the various sections, which include such names as those of Sir George Kekewich, Lord Rayleigh, Earl Grey, the Duke of Argyll, and other well-known patrons.

There are in all over 30 papers to be presented, and they cover a great variety of topics. The conferences are to be supplemented by a series of popular lectures, to take place daily throughout the month of October; many of these should prove of lasting benefit to the public and the gas industry.

A considerable proportion of the papers and lectures deal directly with lighting. The proceedings will no doubt be of exceptional value to the members of the Illuminating Engineering Society, and we hope that many of them will be present and join in the discussions.

LEON GASTER.

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of "The Illuminating Engineer."

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

THE INTERNATIONAL COMMISSION ON ILLUMINATION.

RESULTS OF THE IMPORTANT CONFERENCE OF DELEGATES TO THE INTERNATIONAL PHOTOMETRIC COMMISSION, WHICH TOOK PLACE IN BERLIN, AUGUST 27TH—30TH, 1913

READERS will recall that at the International Electrical Congress which took place in Turin in 1911, a resolution was passed approving the formation of an International Commission on Illumination, at the initiative of the Illuminating Engineering Society of London.

The need for such an international body was pointed out by Mr. Leon Gaster in his paper at the Congress of Turin, when he suggested that the desired Commission be constituted by enlarging the scope and membership of the Zurich International Photometric Commission. Negotiations have been taking place for some time with a view to making this body fully representative of various countries and different methods of illumination. With this end in view national committees have been formed in the chief countries, and at the fourth meeting of the International Photometric Commission, opened in Berlin by the President, M. Vautier, on Wednesday, August 27th, and lasting until Saturday evening, August 30th, this matter came up for discussion.

There were present forty-five delegates representing the institutions connected with gas and electric lighting and illumination in the following countries :—England, France, Germany, Italy, Austria, Switzerland, Belgium, Holland, and the United States of America.

The President in his opening address, recalled that the International Photometric Commission had been founded by the International Congress of Gas Industries, which took place in Paris in connection with the Universal Exhibition of 1900. All the above-named countries having technical societies representing the gas industry had taken part in this Congress, the object of which was to study the methods to be employed in the photometry of incandescent gas lights ; and to organise investigations on the practical applications of gas. A considerable amount of useful photometric work has been carried out and presented at subsequent Congresses in 1903, 1907, and 1911.

In giving a history of the work of the Commission, the President proceeded to explain the reasons for now enlarging its scope, so as to comprise the study of all illuminants and all questions relating to the science and art of illumination.

This was the first occasion on which delegates from the electrical industry and the illuminating engineering societies had been present, the object being to propose statutes for the new International Commission on Illumination.

After four days' careful consideration of these statutes the Commission was duly declared constituted. It will have the widest scope, the general object of the Commission being to promote the study of all questions relating to the science and art of illumination, and to establish by appropriate means international agreement on all questions connected with questions of Illuminating Engineering. Each country is to have only one vote and to contribute the same amount of money, to the expenses of the central office. All countries interested in the subject of illumination have now an opportunity of forming national lighting committees and of sending delegates to participate in the deliberations of the Commission. In countries where illuminating engineering societies exist it will no doubt be convenient for delegates representing that country to be appointed from among their members. At this meeting a very practical step was taken by Germany in arranging for its representation by the Illuminating Engineering Society in that country, in place of the National Committees formed by other nations, to which the illuminating engineering societies and the gas and electrical institutions all sent delegates. It was also decided that the French language should be used in the official versions of the resolutions and reports of proceedings at meetings of the Commission; but English and German are also used in the deliberations.

The draft statutes were unanimously accepted, but have still to be confirmed by the various institutions represented at this Congress, and cannot, therefore, yet be made public.

M. Vautier was elected President of this International Commission; Vice-Presidents, Dr. Bunte, Dr. Hyde, and Dr. Kusminsky; Treasurer, Herr Weiss. Mr. C. C. Paterson, of the National Physical Laboratory, England, was nominated Hon. Secretary. London will thus become the official centre from which the business of the Commission is transacted.

The next session is to be held in Paris in 1916, by which time it is hoped a good deal of useful work will have been accomplished. A series of sub-Committees on special subjects is being appointed, and it is anticipated that their reports will be available at the next session.

The following were the delegates of the respective countries :—

Germany: Dr. Bloch, Dr. Bunte, Prof. Drehschmidt, Dr. Brodhun, Dr. Eitner, Herr Gorges, Dr. Krüss, Herr Mohr, Dr. Monasch, Prof. L. Weber.

Great Britain: Mr. Butterfield, Dr. Colman, Mr. W. Duddell, Mr. Edgcumbe, Mr. Gaster, Mr. Le Maistre, and Mr. Paterson.

France: Dr. Broca, M. Laporte, M. Janet, M. Massé.

Austria-Hungary: Dr. Kusminsky, Prof. Strache.

United States of America: Dr. Bell, Dr. Hyde, Dr. Kenelly, Mr. Mailloux, Mr. Millar, Dr. Sharp.

Switzerland: M. Filliol, M. Gerwer, Dr. Ott, M. Weiss.

Holland: Prof. Feldmann, Dr. M. de Haas, M. W. Niermeyer, M. J. van Rossum du Chattel, Dr. Terneden.

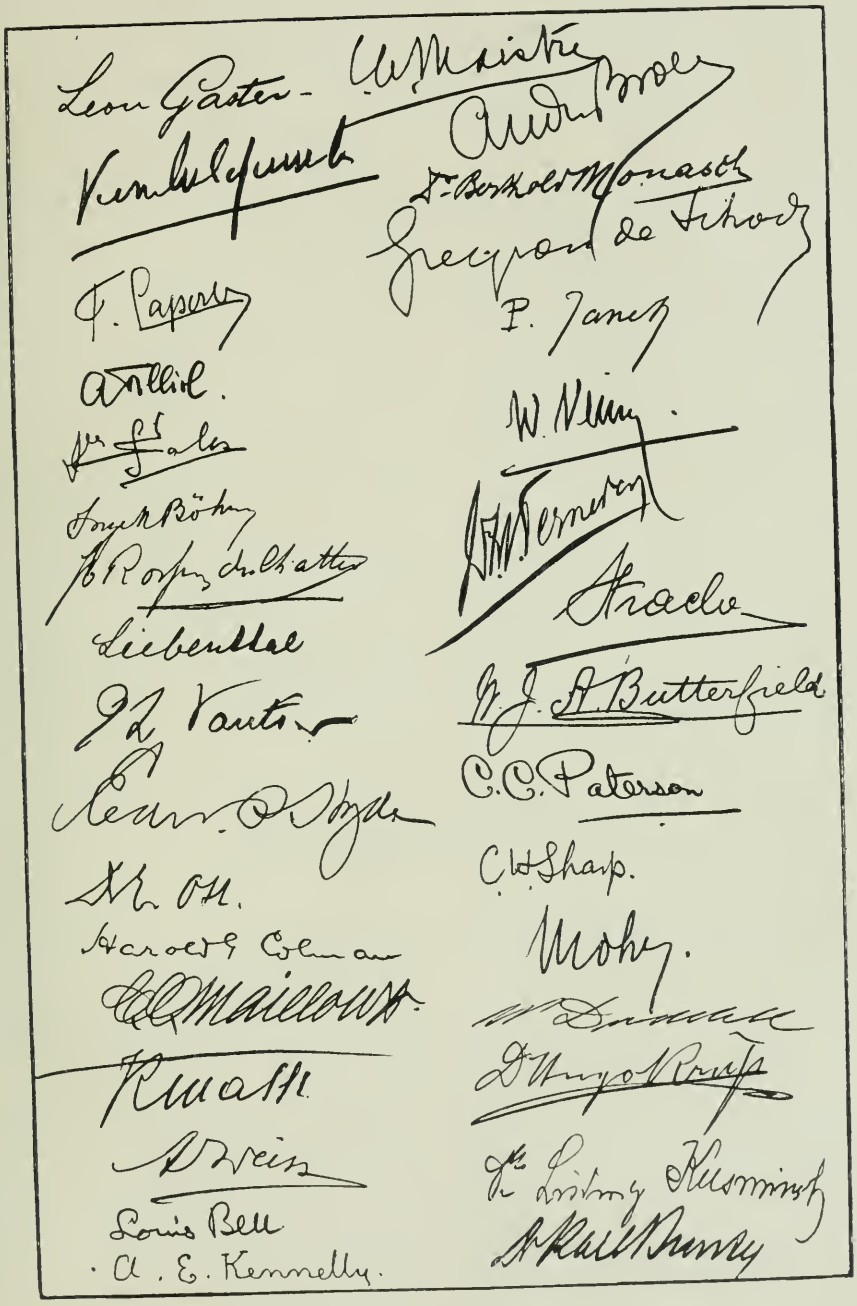
Italy: Sig. Böhm, Sig. Conti, Sig. Clerici, Sig. Sales, Sig. Vallauri.

Belgium: M. Greyson de Schodt.

It is gratifying for those in this country who are interested in the subject of illumination to see that one of the aims of the Illuminating Engineering Society has been so quickly accomplished. Special thanks are due to the President, Mons. Vautier, Dr. E. P. Hyde and Mr. C. C. Paterson, for their labours in connection with this work.

At the conclusion of the proceedings the delegates dined together at the Esplanade Hotel, and they were subsequently entertained as the guests of the German Illuminating Engineering Society, at a dinner given in the Zoological Gardens.

The keen interest taken by all the delegates was a most encouraging sign and there is every reason to hope that the future deliberations of the Commission will bring about a more perfect utilisation of existing illuminants, thus paving the way for future progress.



AN INTERESTING MEMENTO OF AN HISTORIC OCCASION.

Facsimile of signatures of delegates on the menu of the dinner given at the Esplanade Hotel during the Congress.

THE INTERNATIONAL ELECTROTECHNICAL COMMISSION.

(Second Meeting held in Berlin, September, 1913.)

The second meeting of the Electrotechnical Commission, which took place in Berlin last month, was attended by about seventy delegates from twenty-four different countries.

Reports from various committees were presented and discussed, and some important resolutions taken by the subsequent plenary meeting.

A list of about eighty different terms and definitions was adopted, including German and Spanish equivalent terms additional to those already adopted in English and French. There was also an important report presented by the National Physical Laboratories of London, Paris, Berlin, and Washington dealing with the international standardisation of copper.

Other items included the terminology of water power, for which a number of new symbols were proposed. There was a prolonged discussion on the rating of electrical machinery. Although distinct progress has been made towards the settlement of this thorny question, it was agreed not to adopt formal resolutions on the subject, and the points in discussion are being referred back to the National Committees.

In the course of the meeting Mr. L. Gaster made a brief reference to the proceedings at the meeting of the International Photometric Commission, just terminated. In view of the resolution on the subject passed at the International Electrical Congress in Turin in 1911, he thought it desirable to bring to their notice the step now taken to form the International Commission on Illumination, by suitably enlarging the membership and functions of the International Photometric Commission.

The President-Elect for the next two years is Mr. Maurice Leblanc, and the Hon. Secretary, Col. R. E. Crompton, has been re-elected. Special thanks are due to the General Secretary, Mr. C. le Maistre, to whose efforts the success of the meeting was largely due.

The next meeting of the Commission is to take place in 1915 in San Francisco. Prof. M. de Châtelaine, on behalf of the Russian National Committee, invited the Commission to meet in St. Petersburg in 1917.

GLARE FROM POLISHED PAPER.

A short note on this subject has been issued by a committee appointed by the American Illuminating Engineering Society.

It is remarked :—

" The only effective method of removing this cause of eye-strain is to eliminate glazed or polished surfaces from general use. Glazed paper is the greatest offender in producing eye-strain, although other polished surfaces such as glossy ink, glass and varnished desk tops, blackboards and glazed walls are bad enough. Several journals have already adopted unglazed paper, having recognised the necessity for catering to the comfort of their readers. Among the 'remediable causes of eye-strain in present school conditions' embodied in the report of the Association of Women Principals of New York City glazed paper receives the first consideration, with the recommendation 'That hereafter no calendered or coated paper be permitted in the textbooks given to the children, as the dazzle of such paper is injurious to their eyes.' "

The chief difficulty at present is the effective presentation of half-tone blocks.*

In the note issued by the American Illuminating Engineering Society the inside is printed on polished paper and the cover on mat paper, with a view to illustrating the difference in effect with the two materials.

* The recent reprint of " Light and Illumination; Their Use and Misuse " from these columns, issued by the Illuminating Engineering Publishing Co. (Ill. Eng. Dec., 1912), will show what can be done in this direction.

INTERNATIONAL CONGRESS ON SCHOOL HYGIENE.

HELD AT BUFFALO, NEW YORK, AUGUST 25TH-30TH.

AT the Fourth International Congress on School Hygiene held at Buffalo, New York, from August 25th-30th, a Joint Session was held with the American Illuminating Engineering Society. The list of papers being as follows :—

First Session, Friday, August 29th, 2 p.m.

"The Illumination Primer of the Illuminating Engineering Society"—E. L. Elliott, Consulting Illuminating Engineer, 489, Fifth Avenue, New York City, N.Y.

"The Relation of Illumination to Ocular Hygiene"—E. M. Alger, M.D., Professor of Diseases of the Eye, New York Graduate Medical School, 40, East 41st Street, New York, N.Y.

"The Efficiency of the Eye Under Different Systems of Lighting"—C. E. Ferree, Professor of Psychology, Bryn Mawr College, Bryn Mawr, Pa.

"Glare from Paper"—M. Luckiesh, Physicist, National Electric Lamp Association Physical Laboratory, Cleveland, Ohio.

"Influence of Blackboards' Position on Lighting of Desks"—Mathilde Gstettner, M.D., Assistant Oculist Vienna Polyclinic High School, Secretary Austrian School Hygiene Association, Vienna, Austria.

Second Session, Saturday, August 30th, 9 a.m.

"School House Lighting"—Dr. D. W. Weaver, County Commissioner of Health, Greensburg, Ind.

"The Illumination of Class-rooms"—Dr. James Kerr, Department of Education, London County Council.

"School House Lighting in General from the Standpoint of an Engineer"—B. B. Hatch, Electrical Engineer, 120, Boylston Street, Boston, Mass.

"Rural School Illumination"—W. L. Coffee, School Commissioner, Cheboygan, Mich.

"The Practical Methods of Testing Light in School Rooms, with a Demonstration of the Photometer for Lighting Tests in School and Work Rooms"—George Fitz, M.D., Peconic, Long Island, N.Y.

HYGIENE OF VISION.

Among the papers on this subject special interest attaches to that by Dr. E. M. Alger, who presented an analysis of the chief defects in artificial lighting at the present day, laying special stress on the injury that may be done to the retina by unduly bright lights. By focusing the sun's image on the retina permanent blindness may be caused. But a very important influence is exercised by the adaptation of the eye, and if the change is not too sudden the retina can accommodate itself to enormous changes in brightness.

Unsteady lights are also injurious ; it is possible that even a slight flicker in the lights, of which the observer is unconscious, may nevertheless have a trying effect on the eye. It is important to note that while daylight, generally speaking, is most pleasant to the eye, there are certain defects that need to be carefully guarded against, and the fact of light coming entirely from one side of the room from the windows is not always advantageous.

Mr. Lancaster pointed out how very variable daylight illumination in a schoolroom may be. Light surroundings, have an important effect in diffusing the light and getting better uniformity. Reference was also made to the use of prismatic glass. Some of those present believed in overhead sky lighting when possible, but the opinion was also expressed that light coming from directly overhead is inadvisable and it was suggested that skylights should be made of glazed or ribbed glass, which has the effect of distributing the light. Mr. Ward Harrison referred to a school in which the glass area in the ceiling was about 20 per cent. of the total floor area, and artificial light sources were hung directly below the glass giving a distribution of artificial light quite similar to that of daylight.

Direct, Indirect, and Semi-Indirect Lighting.

The discussion of the efficiencies of different systems of lighting revealed decided differences of opinion. Prof. C. E. Ferree described some tests on eye fatigue which seemed to suggest that indirect lighting gave better effects than direct systems and that in any case the conditions of fatigue were more obvious than by daylight. On the other hand, Dr. Miles Standish thought that such conclusions should be accepted cautiously, for in his experience many people complained of indirect systems. Dr. James Kerr suggested that the results would depend on the system of testing. Possibly Professor Ferree would have come to different conclusions had he used as his criterion the threading of a number of needles in a given time. Mr. G. H. Stickney thought that no definite conclusion could be reached on the question of the eye-fatigue caused by direct and indirect systems of lighting until more evidence was available.

Effect of Glare from Paper.

The contribution by Mr. Luckiesh on this subject was designed to show how readily the use of highly glazed papers might defeat the aims of the lighting engineer. He referred to the work of the Committee of the Illuminating Engineering Society (U.S.A.) on this point, of which he was chairman, and exhibited a booth in which the comparative effects of mat and shiny paper could be compared. For school books mat paper is naturally preferable and there seems a need for a standard in this respect. The design of well-distributed systems of lighting and the use of light surroundings are also of service in avoiding inconvenient reflections from paper, polished surface of desks, tiles, &c.

Dr. Roeber mentioned that the Pennsylvania Commission recommended using mat paper in school books and pasting a slip on the front of each book giving directions how the book should be held and the best position for reading.

Glare and Blackboard Lighting.

The effect of direct reflection from the surface of the blackboard is a matter of great importance. In many cases it is extremely difficult to avoid regular reflection from a board with light coming from the windows at the side, but Mr. Luckiesh has found that tilting the board in some cases proved beneficial. The best solution of the problem is to use blackboards with a dead mat surface. One of the speakers suggested that a dull brown colour was preferable to dead black. Another proposal was that a roll of white paper, on which figures could be marked in black chalk, should be employed.

Methods of Testing Illumination.

A paper on this subject was read by Dr. George Fitz, who considered acuteness of vision tests an incomplete method of testing illumination, and thought that many of the empirical tests connecting floor area and window space, solid angle of sky possible from the desk, &c., were preferable as far as daylight illumination is concerned. In this connection he referred to the famous work of Professor L. Weber, of Kiel, and exhibited an apparatus for estimating the approximate sky area visible. A similar device was also shown by Dr. James Kerr. Dr. Kerr also mentioned a method sometimes employed in school-rooms according to which an illumination was considered satisfactory when a standard type could be seen clearly through a dark glass absorbing 96 per cent. of the light.

General Problems in School Lighting.

Papers on this subject were read by Dr. W. Weaver and Dr. James Kerr of the London County Council. Dr. Weaver expressed the view that both direct and indirect lighting are equally suitable with properly designed fixtures. He emphasised the advantage of having lights high up out of the range of view. When this is done the eyes are protected by the brow from the direct rays, and the effects of glare avoided.

Dr. James Kerr laid stress on the great variability of daylight illumination in different parts of the same room. One of the most important points in school-room lighting was undoubtedly the elimination of glare. He mentioned some tests of eye-sight according to which the acuteness

of vision of 20 per cent. of the pupils examined was below normal, while that of ten per cent. was actually only one-third of normal. As regards the position of windows he recommended that the sky-line should not be lower than 25 degrees from the horizontal line to the eye. The problem, in designing school-rooms, is to reconcile the provision of maximum window space (with a view to improving daylight illumination) with the effect of such a large area of glass on the heating and ventilation of the room.

In conclusion, he gave an account of the conclusions reached by the Committee appointed by the British Illuminating Engineering Society, of which he was chairman, and strongly advised that the minimum illumination should not be less than two foot-candles.

It is stated that the Congress was exceedingly well attended, and the idea of promoting an interchange of views between lighting engineers and medical officers seems to have been a great success.

SCHOOL LIGHTING.

Experiences at Salford Technical Institute.

Mr. D. H. Ogley, of the Salford Technical Institute, kindly sends us a copy of a paper read by him some time ago on the subject of school lighting. In this he quotes from a recent report of Dr. James Kerr, and discusses in some detail the question of the best positions of lamps, avoidance of glare, and provision of sufficient illumination.

It is interesting to notice that the general conclusions reached by Mr. Ogley are similar to those put forward now by the Joint Committee appointed by the Illuminating Engineering Society. The same applies to the experiments undertaken by Mr. C. E. Greenslade at the Crawford Technical Institute and described in our August number. In fact, there seems every reason to think that the Joint Committee has succeeded in summarising in its report the views generally held by those who have studied school lighting.

STREET-LIGHTING IN MANCHESTER.

In a recent paper before the Institution of Electrical Engineers, S. L. Pearce and H. A. Ratcliff gave some interesting particulars regarding improvements in Manchester street-lighting. The illumination in two of the main streets, Princess Street, lighted by high-pressure gas, and Portland Street, lighted by flame arc lamps, is exceptionally high, and the authors presented the accompanying comparative data.

	Princess Street. High-pressure gas.	Portland Street. Arcs.
Candle power of lamps	1,750	2,970
Number of lamps to the mile ..	49·34	43·6
Running costs per lamp per hour	1·5d.	0·7d.
Capital cost per mile of street ..	£2,537	£1,569
Running cost per 1,000 C.P. hours	0·857d.	0·236d.
Cost per annum per mile, equal illumination	£675	£254
Minimum illumination, basis of comparison	0·39 f.c.	0·5 f.c.
Cost per mile of street per annum (up to 11 o'clock) at above illumination	£617	£254

THE LIGHTING OF SCHOOLROOMS.

Some Notes on the Report for the Year 1912, Issued by Dr. Meredith Young, Chief School Medical Officer to the Cheshire County Council.

From the valuable report issued by Dr. Meredith Young it would appear that three factors in school hygiene—the eyesight of the children, the nature of the type and paper used in books, and the lighting (natural and artificial)—need to be considered together.

Eyesight Returns.

In some cases the percentage of children with defective vision is decidedly high, and there is little doubt that faulty conditions as regards nature of occupation and lighting are mainly responsible. For example, Dr. Cameron Gibson (Mid-Cheshire) reports that of 2,458 children tested, 19 per cent. proved to have defective vision. In general, as the following figures show, defective eyesight is most prevalent in an urban population :

		No. examined.	No. with defective sight.	No. of these wearing glasses
Boys	Rural	569	78 (13·7 %)	24 (31 %)
	Urban	744	167 (22·4 %)	52 (34 %)
Girls	Rural	511	75 (14·7 %)	20 (27 %)
	Urban	634	158 (24·9 %)	36 (23 %)

Paper and Printing of School Books.

There is no doubt that one of the chief visual defects, myopia, is due largely to excessive close vision, and that outdoor life, participation in games, sports, &c., have a favourable influence in preventing short sight. Obviously therefore the kind of type used in books should be carefully selected. Dr. Meredith Young advocates the standardisation in this respect of text-books for the young, and quotes at length from a recent report of a committee of the British Association. The chief requirements are large type, bold and clear illustrations (complicated pictures with masses of detail are unsuitable for school children), and good paper. The use of glossy paper which gives rise to troublesome reflections should be avoided, and qualities of paper which allow the type on the other side to show through are also bad. Special reference is made to the recent developments in printing half-tone blocks on matt paper. A cream-coloured paper is somewhat preferable to pure white, which somewhat readily becomes soiled.

As an illustration of the size of type for children, it is recommended that the number of letters per inch should not exceed :—

6—7 letters for readers under 7 years of age ;
8—9 letters for readers from 7—8 years of age ;
11—12 letters for readers from 8—9 years of age ;
13 letters for readers from 9—12 years of age :
13—14 letters for readers over 12 years of age.

The length of the line is a matter of some consequence : approximate but not *absolute* uniformity is preferable, and good margins are very restful to the eye. For evening work it is recommended that the conditions suggested for people over the age of 12 should not be departed from—even in the case of adults.

The Lighting of Schoolrooms.

As regards the lighting of schoolrooms, we cannot do better than give the report of Dr. Cameron Gibson *in extenso*. The coloured diagrams (one of which we reproduce in black and white), showing the distribution of illumination in an average room are particularly interesting.

"The instrument used was Bishop Harman's photometer, in which the illumination at the place to be tested is matched by that from a standard candle, the distance of which from the illuminated object can be varied and measured by

TABLE CONTAINING DETAILS OF DR. GIBSON'S INVESTIGATIONS INTO NATURAL LIGHTING OF CERTAIN SCHOOLS.

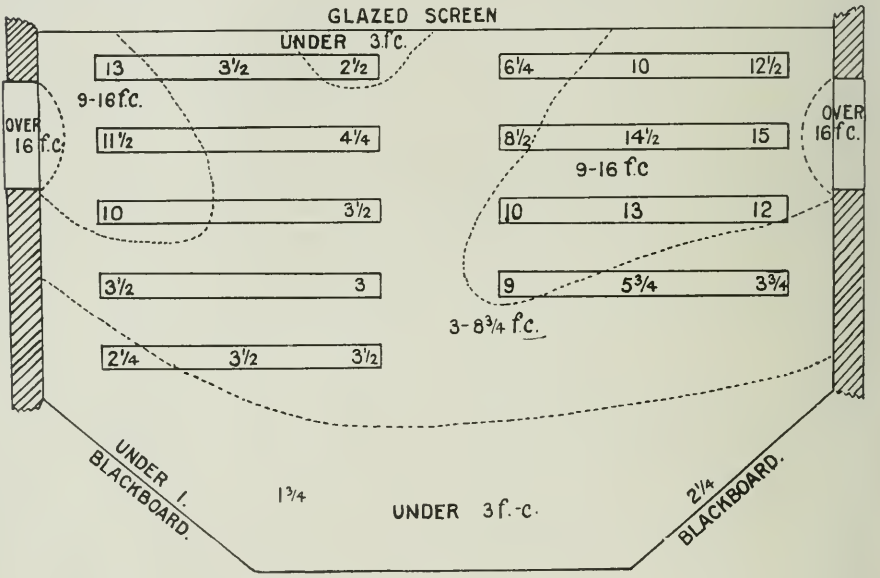
School and Room.	Ratio.— Floor Area. / Glass Area.	Max. Height in inches of Glazing from Floor.	Breadth of Room from Windows in Feet.	Date.	Time.	Actinometer Value. Seconds.	Desk Illumination (Foot-candles). Max.	Min.	No. of places with Illumination under 9.	Blackboard Illumination
1. Sandbach Council (Infants), S.W. Room	11⅛	130	43¾	7th Oct.	11–50	4	over 16	3¾	4	5½
2. Sandbach Council (Infants), N.E. Room	10¾	129	21½	7th Oct.	12–5	15	over 16	10	0	13½
3. Sandbach Council (Mixed), Standard Va. Room	6¼	134 & 157	25	7th Oct.	10–40	8	over 16	13¾	0	16
4. Sandbach (Junior Girls), Room C.	11½	148	33⅛	7th Oct.	2–0	30	16	2¼	29	1½
5. Sandbach (Junior Boys), Room C.	11½	148	33¼	7th Oct.	3–0	90	over 16	1	24	1
6. Nantwich C.E. (Boys), Main Room	7⅜	110 & 160	24	14th Oct.	11–0	20–15	over 16	1	43	3–16
7. Nantwich Council (Senior) Room 6	6¾	135 & 160	25	14th Oct.	11–50	10	over 16	3	20	9–13
8. Nantwich Council (Senior) Room 6	—	—	—	27th Feb.	3–40	40	over 16	7	1	5–14
9. Timber Lane, Northwich (Infants)	9⅜	138	25	21st Oct.	11–15	13–17	over 16	5	8	8–12
10. Paradise St., Northwich, Main Room W.	8	115	20	12th Nov.	2–30	160	12¼	2	31	under 1
11. Paradise St., Northwich, Main Room E.	8	115 & 145	31	12th Nov.	2–40	160	11	under 1	38	9
12. Wharton C.E. (Boys), Room F.	7½	112½	21	18th Nov.	2–40	80–120	over 16	7½	5	5
13. Wharton C.E. (Boys), Room C.	13½	108½	25	18th Nov.	2–30	55–240	14	1	20	6
14. Winsford C.E., S.E. Room	8	129 & 152	24⅛	18th Nov.	11–30	35–95	over 16	3¾	(16)	13
15. Wheelock Wesleyan (Infants), S. Room	10	103	17½	17th Dec.	10–50	35	over 16	5½	1	16
16. Crewe Secondary, 1st Floor, E. Room	7	125	18¾	26th Nov.	12–45	60–200	over 16	8½	1	11
17. Crewe Secondary, 1st Floor, N. Room	6¾	125	21	26th Nov.	1–0	60–200	over 16	6	4	10
18. Crewe Secondary, Ground Floor, E. Room	7¾	125	20	26th Nov.	1–15	250	over 16	under 1	16	3½
19. County Training College, Large E. Room	8¼	141	22⅛	26th Nov.	10–45	40–55	over 16	6¼	7	4¼
20. County Training College, Sewing Room, 1st Floor	7	Roof-light	—	26th Nov.	11–45	55	over 16	over 16	0	9¼

mechanical means. The illumination is then read off in "foot-candles"; a light of three foot-candles means such a light as would be given by three standard candles at a distance of one foot from the object. Further, Bishop Harman suggests that the minimum illumination advisable is nine foot-candles for daylight or three foot-candles for artificial light, measured by his instrument. The intensity of daylight varies very much according to the state of the sky, the hour of the day and the season, so that in order to compare the natural illumination in one room with that in another one requires some measure of the intensity of the daylight that obtained outside at the time that the light inside the room was estimated. This was accomplished by means of a photographic exposure meter in which the time taken for the light to darken a piece of sensitive paper to a standard tint is noted, and as the quantity of light that must be absorbed in order to produce the definite amount of chemical change corresponding to the change in colour is constant, the length of time taken is an inverse measure of the brilliancy of the light. That is to say, if, when it takes 50 seconds out in the open to darken the paper to the standard tint, the lighting at a certain point in a room is 12 foot-candles, then, when on another occasion it takes 100 seconds outside to darken the paper as before, the illumination at the same point in the room should be found to be six foot-candles. This, however, is only approximately true, as any point in a room is not lit by the whole sky but by a small part of it whose brilliancy may differ very much from the general brilliancy. I have stated above that a minimum daylight illumination of nine foot-candles has been laid down as desirable; in order to decide whether any room is well-lit on this basis, one must premise a certain brilliancy of outside daylight at which this figure of nine foot-candles must be attained at the working points within the room. In the middle of the day, with the air clear, the winter sun may take 50 seconds to darken the sensitive paper to the standard tint, while if the sun be obscured by clouds the time taken may be anything up to 300 seconds, under ordinary conditions of weather; so that one can take as a low standard that the illumination of a room should satisfy requirements with outside light having an actinometer value of 50 seconds, that is to say, weak, wintry sunshine; owing to the variation

NATURAL LIGHTING OF SANDBACH JUNIOR GIRLS' SCHOOL (Room C).

Actinometer Value=30 seconds.

The room is mapped out into sections in which the illumination is respectively *bright* (over 16 foot-candles), *sufficient* (9—16 foot-candles), *insufficient* (3—8¾ foot-candles), *very obscure* (under 3 foot-candles).



SCALE: one inch to four feet.

TABLE GIVING RESULTS OF DR. GIBSON'S INVESTIGATIONS ON ARTIFICIAL LIGHTING BY GAS.

School and Room.	Source of Light.	Height in feet of light from floor.	Area of Floor: sq. ft.	Estimated Consumption of Gas: cub. ft. per 100 sq. ft. of floor per hr.	Desk Illumination (Foot-candles).					Black-board illumination.
					Max.	Min.	Average.	† Diversity Coefficient.	No. of places with illumination under 3.	
Sandbach Technical—Needlework Room	2 Batswing Burners 2 Upright Incandescent 4 Inverted Incandescent	5¼	338	10	7	(½)	3·00	14	12	(½)
Sandbach Technical—Small Art Room	4 Upright Incandescent	9¼	283	6	3½	(½)	1·75	7	all but 2	2
Sandbach Technical—Large Room, North portion	3 Upright Incandescent	7¾	356	3	6	1	3·22	6	11	2¾
Sandbach Technical—Committee Room	8 Batswing Burners	6½	512	8	3½	1	2·70	3½	29	4
Nantwich Technical—Room 7 ..	5 Upright Incandescent	9 and 7	430	5	8	2¾	5·10	2·9	1	3
Nantwich Technical—Room 1 ..	4 Upright Incandescent	9	398	4	12	2¾	7·00	4·4	1	3¾
L.C.C. School, Bamsbury* ..	Upright Incandescent	?	540	2·6	4·1	2·4	3·12	1·71	?	2·0
East Ham School, Hartley Avenue*	Inverted	?	634	2·37	6·0	2·4	4·21	2·5	?	2·6

* The last two are taken as typical examples of satisfactory gas illumination from tables in an article by F. W. Goodenough, The Illuminating Engineer, February, 1911.

† Diversity Coefficient is the ratio between the maximum and minimum illuminations.

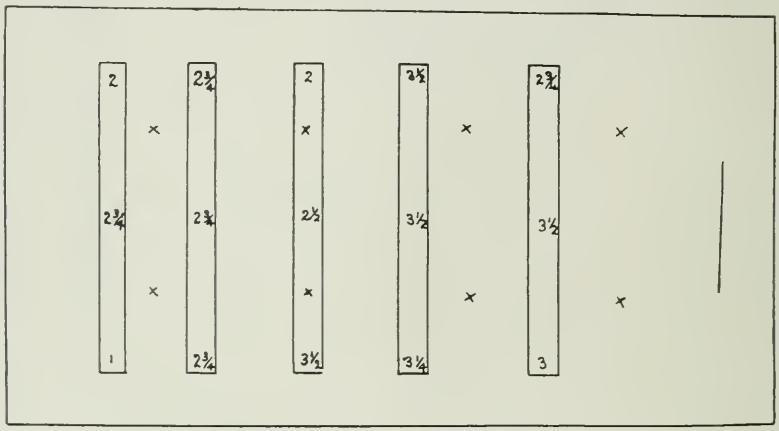
in brilliancy of different parts of the sky, the lighting would need to be measured on several occasions. Many of the schoolrooms examined could not be classed as well lit, but indeed are frankly bad.

"The ratio of the floor area to the glazed area of the windows varied from between 6 and 7 to 1 in the newer schools to between 10 and 13½ to 1 in the older ones. One usually finds in these latter rooms that only a comparatively small portion of the floor is utilized for the children, as the desks are crowded into the part which is well-lit; for instance, in Room 13 with a floor to glass ratio of 13½ in. to 1, 53 children were crowded on to a floor space of 168 sq. ft., next to the windows, with the result that the average illumination of the desks was quite good, but this crowding is very reprehensible for other reasons, such as the communication of diseases and of vermin.

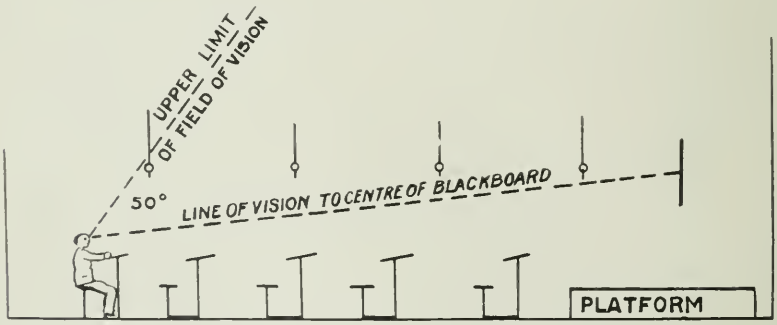
"The width of the room, from the window wall, in association with the height of the window, are other very important factors. With windows twelve feet high the range of good illumination seldom extends further than 18 ft. to 20 ft. from the window. One consequently finds that in the newer class-rooms, with sufficient window-area, and a window height of 12 ft. or a little more, but a width of floor of 25 ft., that the file of desks furthest from the windows, and even sometimes two files, are empty of children, owing to their poverty of lighting. The furthest desks receive light from the lowest

SANDBACH TECHNICAL SCHOOL COMMITTEE ROOM.

(Artificial Lighting.)



Plan showing values of artificial illumination from eight unshaded gas jets (two to each pendant). Their positions are marked by a cross (×).



Elevation showing position of lights in field of vision.

fourth only of the sky, part of which is likely to be obstructed by buildings or trees, and also the light necessarily falls at a very low angle and is more spent in useless reflection than in illumination. The lower the window, the less the width of floor that can be well illuminated. Occasionally one finds that the passage of light through the windows is obstructed by obscuring of the panes or by curtains. In certain of the diagrams appended I have shewn the improvement in the lighting resulting from the removal of bead curtains from the lower half of the windows.

"The lower limit of the glazing, or height of the sill, is as much as five feet above the floor in some infant rooms. The part of the floor next to the window wall cannot then be well utilized, as the lighting is defective.

"Doubtless the colouring of the walls, ceiling, &c., has an effect on the illumination of the room, but this could not be clearly traced, owing to the largeness of the other factors.

"Even in a well-lit room the disposition of the desks so that the children sit with their backs to the light may reduce the illumination on the books to much below the minimum desirable; when measured, the light on the desk in the shadow of the child's head was found to be from one-third to one-ninth of what it was clear of the shadow. The position of the blackboard is also of importance.

"Some plans are given showing the illumination at various points in selected classrooms.

"Opportunity was also taken to measure the **artificial lighting** in the buildings used for Evening Classes at Sandbach and at Nantwich, the results of which are given in the accompanying Table.

"The photometer used gives at once comparable estimations of artificial lighting. The illumination at the Nantwich Technical School is very good; at the Sandbach Technical School it cannot be called good in any of the rooms, and in the Committee Room used for the teaching of geometry and drawing it is very bad. Not only is the illumination on the desks weak, but the sources of it are so disposed that an occupant of the back desk, on looking at the blackboard, will have at least six, and possibly eight, naked gas-flames in his field of vision, surrounding and actually in front of the blackboard. Further, the large consumption of gas overheats the room, and that, with the products of combustion, makes the atmosphere oppressive. An improvement in the lighting of this building might be found to be a very real economy."

These investigations are in my opinion exceedingly valuable, and I propose to extend them to a number of other schools, and to draw the attention of the Managers to cases requiring attention on their part. Dr. Cameron Gibson is to be greatly commended for the skill and careful attention to detail exhibited by him in conducting the investigations.

Dr. Jubb (West Cheshire) writes as follows:—

"During the year the lighting has been improved in several schools. Some infant schools are still provided with galleries, and these are objectionable in many respects—not the least being the interference with proper lighting.

"School windows ought to be cleaned oftener than they are at present; once a month would not be too often.

"The artificial lighting of many schools requires attention. A few schools are still unprovided with artificial light. During the winter there are many dark days, when some form of artificial light is required, and in any case the school cleaning, which is carried out after school hours, cannot be satisfactory, unless a good light is provided."

It is interesting to notice that an exceptionally complete series of lectures on school hygiene is arranged for Assistant Medical Officers. This includes a section on lighting and warming, where attention is called to the effects of "Sunshine and diffuse light. Artificial light—lamps, gas, &c. Bad effects of insufficient light and of flickering, glare, &c."

"UNILATERAL" VERSUS "BI-LATERAL" LIGHTING.

In *The Builder* there is a note on school lighting by Mr. G. H. Widdows, architect to the Derbyshire Education Committee, who describes a special method of avoiding the defects of "bilateral" arrangements—*i.e.*, light entering from windows on both sides of the room. It is stated that this was suggested partly by a recent visit of the sub-committee of the Illuminating Engineering Society, now engaged in studying the natural lighting of schools.

THE NATIONAL GAS CONGRESS AND EXHIBITION.

To be officially opened on the 1st of October.

In our last number we gave a list of the chief papers to be presented at the National Gas Exhibition, dealing with lighting. The complete programme has now come to hand. We find that there are to be over thirty different papers presented at these conferences, which are allotted to the following subjects :—

1. *Oct. 4th.*—A Conference on Food and Cookery (President : The Most Hon. the Marquis of Lincolnshire).

2. *Oct. 9th.*—A Conference on Smoke Abatement (President : His Grace the Duke of Argyll).

3. *Oct. 11th.*—A Conference of Educationalists (President : Sir George W. Kekewich).

4. *Oct. 14th.*—A Conference on Lighting and Heating (President : Sir Rickman J. Godlee).

5. *Oct. 17th.*—A Conference on Some Aspects of Scientific Illumination (President : Lord Rayleigh).

6. *Oct. 24th, 25th.*—A Conference on the Economics of the Home (President : Viscount Dunluce).

7. *Oct. 28th.*—A Conference of Employers (President : Earl Grey).

8. *Oct. 29th.*—A Conference of Manufacturers (President : The Rt. Hon. Lord Weardale).

At these Conferences the following papers are to be presented dealing with various aspects of illumination :—

Oct. 11th.—Some Considerations on the Brightness of Lights, by Professor Silvanus P. Thompson.

Oct. 17th.—The Physiological and Mental Disadvantages of Unscientific Illumination, by Leon Gaster.

The School of the Future: its Lighting, Heating and Ventilation, by S. Warwick, F.R.I.B.A., and A. Hall, F.R.I.B.A.

Oct. 14th.—The Hygiene of Gas for Lighting, by Dr. S. Rideal.

Oct. 17th.—The Aims and Objects of the Illuminating Engineering Society, by Leon Gaster.

The Economy of Efficient Lighting, by Franklin Thorp.

Light and Sight, by Dr. Meredith Young.

Oct. 24th, 25th.—Fuel and Lighting in the Working Man's Budget, by Mrs. Margaret McKillop.

Oct. 29th.—The Lighting, Heating and Ventilation of Factories and Workshops, by Professor Vivian Lewes.

The Economic Value of Adequate Illumination, by Leon Gaster.

The Matching of Colours by Artificial Light, by T. Thorne Baker.

The daily Popular Lectures will take place every weekday at 8 p.m., and the display of lantern slides, photographs, diagrams and models will be a special feature.

We are also given to understand that the exhibits will be of more than interest. The method of grouping together all exhibits of one kind is to be adopted. In one section all types of gas instruments, photometers, &c., will be on view, in another there will be practical demonstrations of mantle manufacture. There will also be a number of rooms given up to demonstrations of methods of illumination. Several rooms are to be fitted up with desks and blackboards to imitate miniature schoolrooms, offices, &c., and lighted by direct and semi-indirect means ; and it is proposed to equip a series of booths with wallpapers of different colours so as to illustrate the effect of reflection in an average room. In the street-lighting section all the latest methods, including "staggered lights," and central suspension will be on view.

We understand that the general lighting of the exhibition will also be interesting, and that semi-indirect methods will be a feature. A novel form of coloured sign lighted by concealed lights has also been arranged over the entrance to the exhibition.

A NOVEL METHOD OF LIGHTING EXHIBITION HALLS.

Abstract of a paper by Mr. R. F. Pierce appearing in the Transactions of the American Illuminating Engineering Society for June, 1913.

In the lighting of exhibition halls something novel and striking is wanted, in spite of the fact that the conditions often necessitate a temporary, more or less "make-shift" installation. For example, it may not be convenient to use hanging fixtures and the ceiling may be an artificial one composed of silk or canvas hangings. For this reason pedestal lighting has advantages. This method is advocated by Mr. R. F. Pierce in a recent number of the Transactions of the American Illuminating Engineering Society. He describes the lighting of a hall by ornamental Corinthian pedestals equipped with gas mantles. The nature of the fitting will be understood from Figs. 1 and 2. The gas is led up through the pillar, at the top of which a cluster of 15 upright incandescent gas burners is mounted. The lights are within a shell-like bowl of decorative glass, designed to screen the mantles

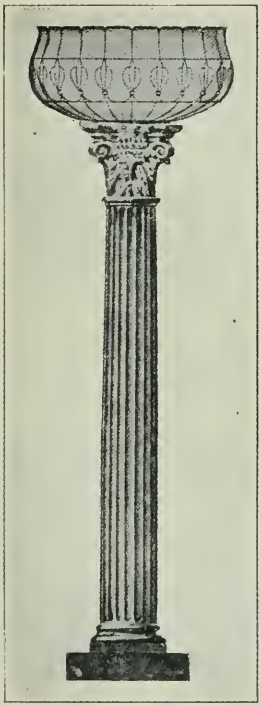


Fig. 1.—General view of semi-indirect fitting on Corinthian ornamental pillar.

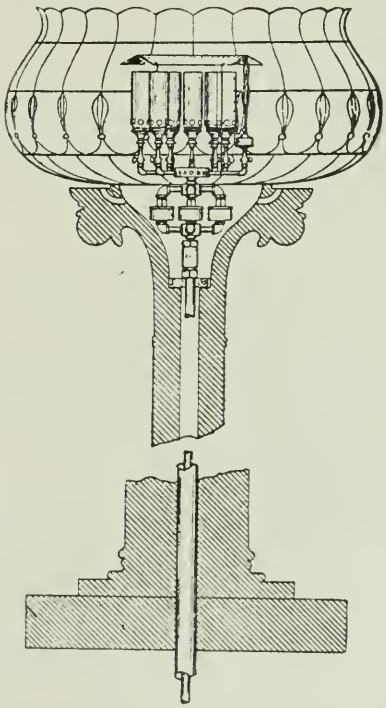


Fig. 2.—Showing method of leading gas into the diffusing bowl fitting.

from the eye and direct a considerable portion of the light upwards on the white ceiling. These pedestals were placed in the manner shown in Fig. 3, ten units in all being employed. An illumination of about eight lumens per sq. ft. (8 ft-candles) was considered desirable for the floor. The total area of the hall (about 5,900 sq. ft.) would therefore require a flux of about 47,000 lumens. The walls in this auditorium were dark green, which, with this fixture, would mean a utilising efficiency of only 40 per cent. The total number of lumens to be generated should therefore be 120,000. It was decided to employ ten units each providing about 12,000 lumens.

The lighting is of the semi-indirect character, just about fifty per cent. of the light being directed upwards. The large direct component is considered desirable for exhibition lighting in order to avoid any impression of flatness. Fig. 4 gives an idea of the appearance of the complete installation. The method is said to have been quite successful. It is one that might often be employed with advantage when it is desired to produce a novel lighting effect without interfering with the walls and ceilings of a room.

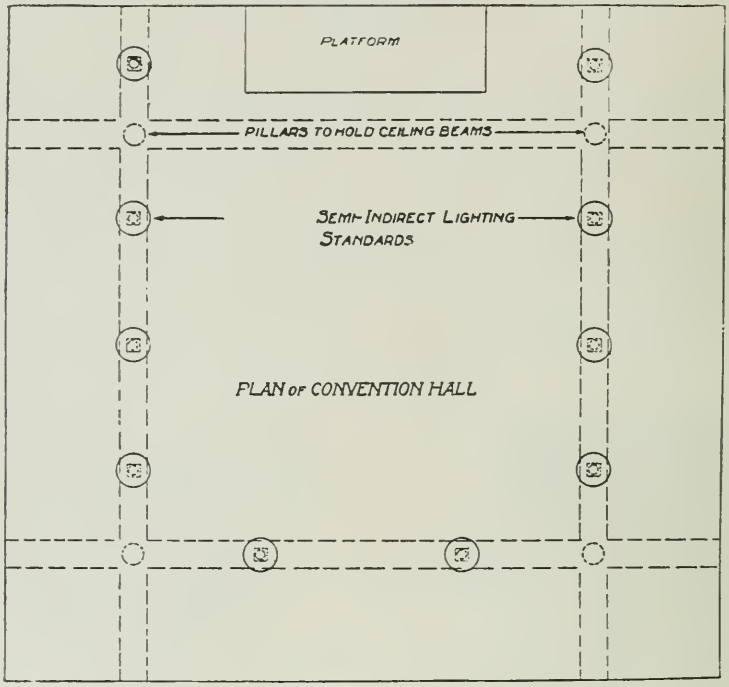


Fig. 3.—Plan of Hall showing position of pedestal lights.

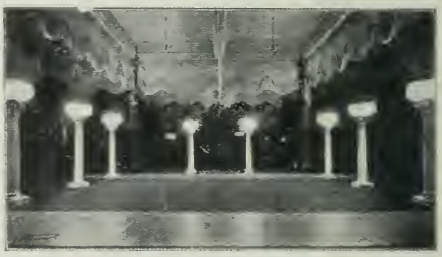


Fig. 4.—General view of the Hall showing pedestal lighting.

THE ELECTRIC LIGHTING OF A COVERED LAWN TENNIS COURT.

It is now about two years ago since we first described the lighting of the Coverned Lawn Tennis Courts at Dulwich, by high-pressure gas.* At that time the use of artificial light in sport was a comparative novelty but it is now becoming quite common, and several examples have been mentioned in these columns from time to time.

The employment of artificial light is, of course, a very decided advantage in a covered lawn tennis court. It enables play to go on by night when daylight has failed and irrespective of the climatic conditions. In the short winter days when fogs are frequent, play would naturally be much restricted if one had to depend solely on daylight. It is this possibility of playing during the winter which is the most important advantage of covered courts, and in the lawn tennis world the success of Continental experts has been often ascribed to the fact that they practice so assiduously during the winter. In addition, it need scarcely be said that the majority of busy people can only rarely obtain time for a game of tennis during the daytime, and for these it is naturally a great boon to be sure of some play after business hours are over.

The installation we are now about to describe is the covered law tennis court at the Rackets Club in Parliament Street, Liverpool. The club is a wealthy one, has very fine premises, where quite a number of different games are played. There are, for example, five squash racquets courts, one racquet court, and one fives court. Several of these courts are lighted artificially, but the new lawn tennis court is much the most interesting installation. The nature of the building will be understood from Figs. 1 and 2. The floor area is 120 by 56 feet, which allows ample space for players to run back outside the court. There is a clear headway of 30 ft. and the large skylight overhead enables full advantage to be taken of the natural light during the daytime. The area of the glass and the height of the building are so arranged that the direct rays of the sun do not strike the surface of the court, but are reflected from the white walls. The players, therefore, utilise only reflected light and skylight, and are not troubled by any glare from the sun.

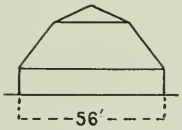


Fig. 1.—Side elevation of building.

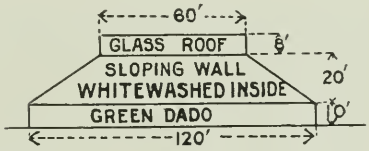


Fig. 2.—Front elevation of building.

The floor is painted with a dead black preparation, the lines being white. This black surface is considered essential in a covered lawn tennis court lighted by artificial light in order that players may see the balls easily. It is desirable to get a good contrast between the balls and their background, and the dead surface prevents inconvenient reflections of the sources of light. A dark floor is also desirable in order to avoid the multiple

* Illum. Eng. Lond. Vol. III., 1911, p. 273; see also Vol. VI., March 1913, p. 141.

shadows of moving balls. If the court were made of light tinted material such shadows would be distinctly visible and of course trying to the players when following the course of the ball. In cases where indirect lighting can be employed this effect would doubtless be less evident; but nevertheless, for the other reasons stated, a dead black surface would still be desirable. It will be recalled that in the courts at Dulwich the background as well as the floor, are all dead black. In this case a somewhat different method has been employed. The dado round the courts is of a light green colour (which the players preferred as being more natural and soothing to the eyes), and the sloping roof on either side of the skylight is whitewashed. This change is considered an advantage from the lighting standpoint, since it enables a certain amount of reflection to be obtained, giving better diffusion and less pronounced shadows.

The floor is lighted artificially by a series of eight 1,000-c.p. tungsten lamps spaced four on either side of the court in the manner shown in Figs. 3 and 5, and hung at a height of 28 feet. These lamps are concealed from the eye by specially shaped reflectors (see Fig. 3). They are made of steel lined with Chappuis silvered glass and have a wire

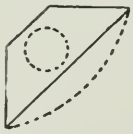


Fig. 3.—Diagram showing shape of reflector. The wire gauze protection is shown dotted.

gauze in front. In addition there are blinkers at each side so that it is impossible for a player in any ordinary position to catch a glimpse of the filaments.

As will be seen from Fig. 5, there are also two 200-c.p. lamps in conical reflectors placed above the surface lines at each end of the court in order to accentuate the illumination at these points. There is thus a total c.p. of 8,800 employed.

The total electrical energy consumed may be estimated to be approximately 10,000 watts, *i.e.*, 10 units per hour. Current is obtainable for the court at 2½d. per unit, so that the cost of the artificial light for one hour's play on this court would be approximately 2s. 6d. The consumption works out to about 1·5 watts per sq. ft. of floor. We hope shortly to be able to give the results of some measurements of the illumination in these courts.

The advantage of this system of illumination by concealed sidelights is evident from the figure. The player, gazing down the length of the court, has a clear view of the ball and his opponents without being troubled by any inconvenient lights, and the sources are completely screened from his view. Even the eyes of a person standing near the net need not encounter these sources unless he turns sideways and gazes upwards—a position probably very rarely assumed by a lawn tennis player. It is interesting to recall that in the Dulwich courts lamps were originally suspended at intervals immediately above the court, but this arrangement has been replaced by a system of side lights which is considered a distinct improvement.

Figs. 4 and 5 are interesting as showing the comparative conditions by day and artificial light. An interesting question that naturally arises in a court of this kind is whether players find any difficulty in accustoming themselves to the change from natural to electric light. It might be supposed that when twilight came on a certain interval of time might be necessary for the eyes to become used to the new conditions. It is stated, however, that this has not been very noticeable. In fact in one case the artificial lights were turned on one at a time as the daylight began to fail, but the players went on with the game without being conscious of the change.

For the particulars of this interesting installation we are indebted to the courtesy of the consulting engineer, Mr. H. M. Rootham, B.Sc., A.M.I.C.E., who was also responsible for the design of the Covered Lawn Tennis Courts at Dulwich.

FIG. 4.—A daylight view of the court illuminated from the skylight above.

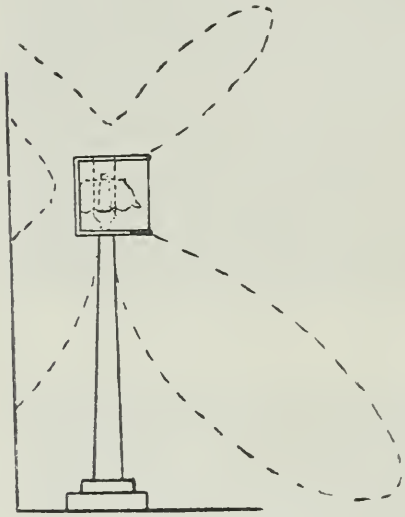
FIG. 5.—View taken entirely by artificial light, showing side-lighting by tungsten lamps in special reflectors.

The Covered Lawn Tennis Court at Liverpool (Parliament Street).

THE IMITATION OF DAYLIGHT.

(Abstract of a portion of a paper published by Dr. H. E. Ives in the Transactions of the American Illuminating Engineering Society, June, 1913.)

We are familiar with appliances using specially tinted glass to give a quality of light closely resembling daylight in colour. But it must be remembered that the mere imitation of the colour does not constitute an exact reproduction of daylight. Complete similarity would involve an imitation of the conditions as regards *distribution* of light. It may be noted that daylight in general is received from side windows in a room and not from overhead. It is, therefore, hardly possible to get a true daylight effect by illuminating the ceiling. It would be necessary to analyse very carefully the distribution of light in the room during the daytime and arrange the nature and position of artificial sources to give the same impression. It may also be noted that it is not enough merely to get the *ratio* of illumination in different parts of the room the same. It appears that in order to get exactly the same effect the absolute values of the illumination should be identical. Otherwise the impression received by the eye does not seem natural.



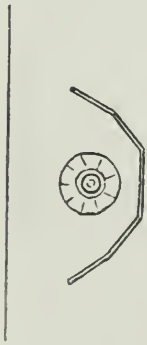


Fig. 1.—A side wall unit approximating to window conditions.

Some ingenious experiments in this direction are described by Dr. H. E. Ives in the Transactions of the American Illuminating Engineering Society for June. The standard fixture shown in Fig. 1 is one means of getting fairly close to daylight conditions. It will be observed that the screen in front of this light blocks out the direct rays and so that the eye cannot see the source, but allows a large part of the light to

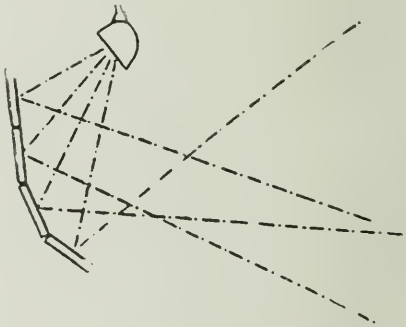


Fig. 2.—Section of reflector illuminated by concealed lights and designed to imitate the light from a window.

strike the wall behind and to pass upwards to the ceiling. In order to get the best effect care must be taken not to get the wall too bright. By a little ingenuity it is possible to keep the brightness within such limits that the face of a person can be easily distinguished with the wall as a background and the "silhouetting effect" is avoided. Quite apart from the attempt to imitate daylight, a standard of this kind would doubtless be a useful appliance in many rooms with fairly light walls.

One of the most interesting devices described by Dr. Ives is the artificial window shown in Fig. 2. This consists of a specially shaped reflector illuminated by a concealed source. It is so shaped that, when illuminated, the reflected rays produce an impression very similar to that of the window, the comparative brightness in different parts of the room being almost the same as by daylight. The material for the reflector must be selected with some care in order to give exactly the right distribution of light. A ribbed mirror glass, sandblasted on the front and then slightly rubbed with oil was found to give the best results. The arrangement of the reflector in the room is shown in Fig. 3.

Dr. H. E. Ives summarises the chief requirements of daylight imitation as follows:- (1) Direction from the side; (2) soft shadows and low intensity of specular reflection, due to the large size of the source; (3) the direction of a large part of the light on the lower and darker parts of the room; and (4) concealment of the principal light sources. In addition, we may add (5) the quantity of light needed to imitate daylight successfully will be exceptionally large. It may be noted that the effect produced will depend to some extent on what kind of daylight one selects; for example, the effect on a foggy day is very different from that when bright sunshine prevails.

When the sun is shining through a light mist an intermediate condition of affairs is met with. In short, in natural lighting we meet conditions analogous to direct, indirect, and semi-indirect lighting.

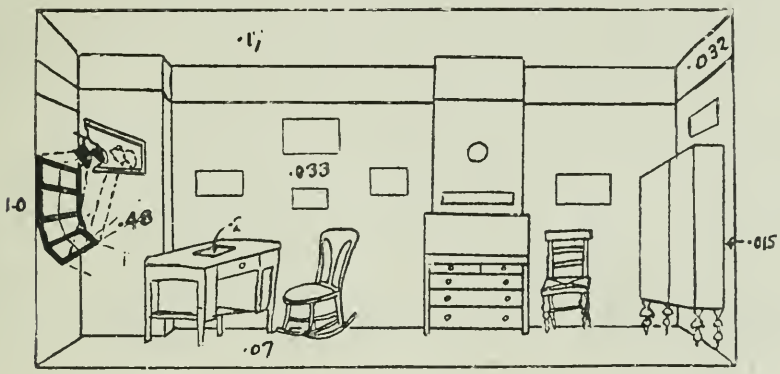


Fig. 3.—A room lighted by the fitting shown in Fig. 2.

Daylight illumination, although superior to artificial light in many respects, is not always ideal. The variation in illumination in different parts of one and the same room illuminated by daylight may be very great, and the changes according to the period of year, time of day, and climatic conditions must also be borne in mind. Our object should be to imitate the desirable qualities, but not to perpetuate the defects. There is a great deal to be learned by studying the differences and resemblances between natural and artificial light.

AN ORIENTAL RESTAURANT IN NEW YORK.

The picture shows the method of lighting adopted by the Edison Company in a new restaurant in New York, where Chinese and Japanese dishes are a speciality. The style of decoration and lighting are also carried out on Oriental lines, strong masses of colour being used and lanterns hung from the ceiling. The illumination is provided by 10-watt tungsten lamps, 1,200 globes of various colours being used for the interior lighting. These lamps are artfully concealed in the paper lanterns and behind paper panels so that not a single lamp is visible to people seated behind the tables. The illustration gives a good idea of the way this is carried out.

It will be observed that the Chinese dragon is frequently in evidence. The restaurant is equipped with an illuminated name sign carrying out the same intention. Over the entrance there are great Chinese lanterns in which are concealed three arc lamps, giving a decidedly gorgeous effect. Some account of the lighting of this restaurant was given in a recent number of the *Edison Monthly*, to which we are indebted for the illustration.

Photographic Bureau of The New York Edison Co

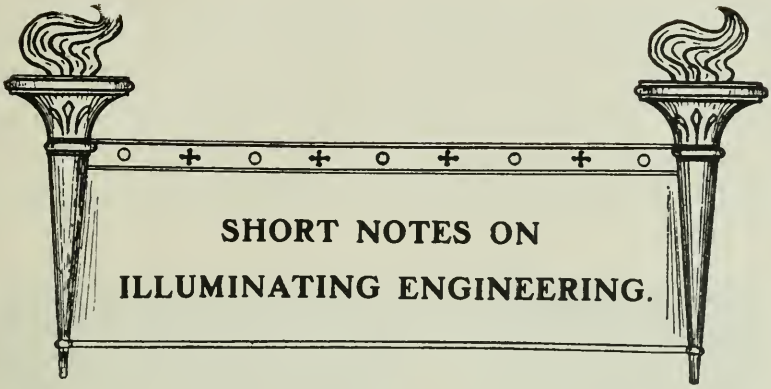
DOVER MISHAP.

Searchlight said to have caused a Collision.

A Dover telegram states that the steamer Lord Londonderry, from Goole, loaded with coals for Dover, ran into the end of the eastern arm, Dover, this morning, smashing the vessel's bows badly.

The ports on the eastern arm of the Admiralty Pier have been manned the last two nights with a searchlight operating on both entrances, and it is thought that this was the cause of the accident, owing to the men on the bridge being blinded.

A Deal galley put into Dover during the night, and the crew said that the glare of the light blinded them.—*Evening Standard*



MODERN CIRCUS LIGHTING.

The lighting of a travelling circus offers quite a field for the illuminating engineer. At one time open flame torches and naphtha lamps were uniformly employed, but recently incandescent oil and paraffin lamps have become much more common. It may be news to many that there are said to be as many as one hundred travelling showmen in England, some of whom demand a considerable amount of light.

Some of the well-to-do travelling circuses provide quite elaborate portable electric lighting systems. We notice from a recent number of the *Electrical World* that both the Barnum and Bayley and Ringling Bros. circuses have used portable plant for lighting the tents by electricity. The electricity is generated by a portable electric gasoline driven set, the units being duplicated so that in the event of one becoming disabled while *en route* the other can take its place. There are also 25 ampère "spot lamps" for the stage and festoons of lamps for decorative purposes, and a waggon equipped with a travelling searchlight which can be directed on any part of the ground while taking the tents down and loading in the night time after the final performance.

LIGHTING IN THE SALVATION ARMY LODGING HOUSE IN NEW YORK.

One of the most interesting districts in New York is the Bowery, which has a unique reputation for rowdyism and is peopled by a very curious set of characters. In this district the Salvation Army is stated to be doing good work and has established the cheap lodging house where waifs and strays can spend the night.

In a recent number of the *Edison Monthly* attention is drawn to a cheap and ingenious method of lighting used in this cheap hotel. Long corridors pass between each set of bedrooms, and the partitions of the rooms only reach to a point 2 ft. below the ceiling. In the corridor electric lights are arranged at frequent intervals. Lamps are placed just a little distance below the partition, rendering the light source invisible to the occupant of the bedroom but directing a certain amount of light on the ceilings. Thus it happens that this cheap lodging house possesses an indirect lighting system of a kind. The light is hardly strong enough for night study and it is doubtless not desired that the inmates should read in bed, a well-lighted general reading room being provided. The illumination is, however, sufficiently good to light the guest to his slumbers.

ILLUMINATING ENGINEERING IN THE KITCHEN.

The illustration below shows how the domestic servant is prepared to deal with modern illuminants. Not infrequently one finds in the kitchen an objection to electric light and a preference for oil lamps. The probable explanation is that the metallic filament lamps are so often equipped with the ordinary shallow opal shade which so frequently fails to screen the eyes from the bright filament.

In this case, by a simple piece of illuminating engineering, the opal reflector has been transformed into quite an effective device. The servant, on her own initiative, superimposed over the opal a green cotton shade with a white lining. In this way the filament is completely covered and causes no annoyance, and the illumination on the kitchen table considerably increased.

A simple device in the kitchen. The servant of her own accord added a cotton shade to the shallow opal reflector, thus screening the light from the eyes and increasing the illumination on the table below.

THE LIGHTING OF BAKERS' OVENS.

In a recent number of *Electrical Investments*, the interesting problem of the best means of illuminating bakers' ovens is discussed. It is often convenient to be able to see the contents of these ovens while the heating is in progress, but experience apparently shows that even carbon filament lamps have a very short life when placed inside. Possibly the explanation may lie in the high external temperature maintained. In any case it would seem preferable to illuminate the ovens from without, and some form of lighting is needed which can penetrate into the recesses of the oven and reveal its interior. Possibly indirect lighting would be advantageous for work of this kind.

TRADE TOPICS.

[At the request of many of our readers we have extended the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

The lighting season is now upon us and is heralded by quite a number of new types of shades and reflectors.

We observe that in stating the advantages of these new units the manufacturers lay stress on the demand for improved types that has been developed by the illuminating engineering movement. It is now recognised that a good shade should adequately screen the source and distribute the light "just where it is wanted."

SUPERLUX GLOBES AND REFLECTORS.

The **General Electric Co.** (67, Queen Victoria Street, London, E.C.) send us their latest catalogue describing the new "Superlux" line of globes, bowls and reflectors, introduced for the first time last month. These are made in four classes, comprising white glassware, and reflectors made respectively of enamelled steel, aluminium and mirrored glass.

The reflectors are made in the distributing and concentrating types and polar curves of each variety are supplied. Chief interest attaches to the white glassware. This is made of a very light variety of glass, matt on the inside and slightly polished on the outside, so as not to collect dust. The glass is claimed to have very good qualities as regards absorption and diffusion. It is thin enough to enable one to read the type on a sheet of notepaper placed behind one of these globes, but nevertheless the filament of a lamp inside is not visible and the surface is evenly illuminated.

It is expected that white glassware of this kind will replace to a great extent the shallow opal types of reflectors still so widely used, which, it is recognised, are open to considerable objection from the illuminating engineering standpoint.

Distributing Reflector.

Concentrating Type.

Diffusing Bowl.

Superlux white glassware.

These various types of reflectors have been installed throughout the offices of the company, so that visitors have an opportunity of judging their effect in practice.

"MARBELLA" GLASSWARE.

Another new variety of white glass shade is the "Marbella," announced by **Messrs. Siemens Bros. Dynamo Works, Ltd.**, Tyssen Street, Dalston, N. These, too, are claimed to be so designed as to give a soft white light and to eliminate glare. The use of rough surfaces and angular projections has been avoided: the shades should therefore be easy to clean and do not readily collect dust. They are made in the concentrating and distributing types as shown in the accompanying illustrations.

Concentrating

Diffusing

"MARBELLA" REFLECTORS.

NEW VELURIA GLASSWARE.

The **British Thomson-Houston Co.** (Mazda House, Upper Thames Street, E.C.) are introducing several new varieties of Veluria glassware. These reflectors are made of white translucent glass, and the two new types have a distinctly novel appearance. One of them resembles the standard "intensive" type, but is equipped with an etched floral design, and the other patterns are also decorative in design and are intended for domestic use.

B.T.H. Veluria Reflector, New Decorative Style.

We have also received particulars of B.T.H. Automobile switches and Rotary Snap switches, which are made in quite a variety of forms.

SHOOTING CONTEST.

On Saturday afternoon, the 6th inst., Siemens Dalston Works Miniature Rifle Club met the Western Electric Company's Rifle Club on their Open-air Range at Plumstead, the result being a win for the Siemens team. The average score of Siemens team was 89·5, the total score being 537 out of a possible 600.

AN INTERESTING CHURCH LIGHTING INSTALLATION.

The illustration shows an interesting Holophane installation in St. Andrew's Church, Derby, where Holophane reflector-bowls are employed. We understand that these comparatively big units are considered very useful for lighting spacious interiors. It is pointed out that the prisms spread out and diffuse the light, preventing anything in the nature of glare, and the mild sparkling effect removes any impression of "flatness" and adds just the necessary touch of "life" to the installation; this effect is very noticeable in the new semi-indirect units.

A view of St. Andrew's Church, Derby, lighted by tungsten lamps in Holophane reflector bowls.

PERSONAL.

We note that Mr. E. P. Barfield, who for several years acted as manager of the incandescent lamp and fittings department of Messrs. Siemens Bros. Dynamo Works, Ltd., has accepted the position of commercial sales manager for the Ediswan Company, and will take up the position early this month.

We are also informed that Mr. S. Boys, who for the past two and a half years has held the position of Supplies Manager to the Sheffield Branch of Messrs. Siemens Bros. Dynamo Works, Limited, is resigning this position to take up an appointment with the Edison and Swan United Electric Light Co.

THE CHANGING EAST.

It would seem that the new illuminants are steadily and surely making their way into eastern countries. The Victoria Cotton Mills, one of the largest in the Cawnpore district, is now illuminated throughout with Osram drawn-wire lamps, which have successfully withstood the severe vibration from the looms and other moving machinery.

GENERAL AGENT. Wanted sole agent for the sale of "Mercury" Switch apparatus to make and break contact of high tension by low tension and bell-wires. Patent in U.K. 2520. Apply to Osborne-Peacock Co., Ltd., 24, Holborn, London, E.C.

HORTICULTURE BY THE LIGHT OF THE MERCURY VAPOUR LAMP.

We have received from the **Westinghouse Cooper Hewitt Co., Ltd.** (80, York Road, King's Cross, London, N.), a copy of a report received from Miss Dudgeon, of Lincluden House, Dumfries, describing the acceleration of plant life under the rays of the mercury vapour lamp.

The experiments were made in two identical houses. One of these was lighted by a mercury arc vapour lamp, which was turned on about an hour before sunset each evening and kept on for about 4½ hours.

Some remarkable results appear to have been obtained. Seeds of French beans, carrots, maize, lettuce, &c., germinated several days, and in some cases several weeks earlier than when grown under similar conditions in the ordinary house. (The temperature in the two houses where the experiments were conducted was practically identical, so it would appear that the light-radiation produces the effect, notwithstanding the fact that the seeds are presumably lightly buried in earth.)

The effect of the light on growing plants appears to have been still more marked. Geraniums, roses, carnations, &c., all responded to the treatment by marked increase in foliage and flowers of good size and colour, and one rose ("Belle Lyonaise") which had flowered all the previous summer and autumn, and was pruned bare in November, again showed leaf in two weeks, in six weeks it showed buds and has continued to bloom ever since. Equally good results were obtained with strawberries which flowered abundantly and gave an increase in crop of 25 per cent.

It is claimed that this method of assisting growth will be very profitable to the market gardener, since there would be a great saving in heat, and the seedlings would require practically no hardening off before being planted in the open.

"LEKTRIK" LIGHTING CONNECTIONS.

The little booklet (price 6d. net) bearing this title is written by Mr. W. Perren Maycock, and is issued by **A. P. Lundberg and Sons** (477–489, Liverpool Road, London, N.). It is of a size to go into the waistcoat pocket, and is intended as an aid to wiremen and electrical contractors.

All the well-known Lundberg specialities are described, and there are clear diagrams illustrating the various methods of controlling lamps independently from a number of different points.

The series of notes on illumination and switching deserve study. We will quote one that will be read with sympathy by many who have struggled to read meters in out-of-the-way corners :—

"There are always out-of-the-way recesses, corners, cupboards, &c., where light is only occasionally or seldom required : but provision should nevertheless be made for lighting these places. **It should never be necessary to use candles, oil lamps, matches, or even portable electric lamps anywhere.**"

In the past the tendency has been to use only single-way switches, and as few of these as possible, so as to keep down the first cost. But, by so doing, much of the adaptability of electricity is lost, and the saving at the beginning becomes poor economy in the long run.

REDUCTION IN PRICE OF TUNGSTEN LAMPS.

The price of tungsten lamps is coming down. The **General Electric Co.** announce the following reductions in the price of Osram lamps :—

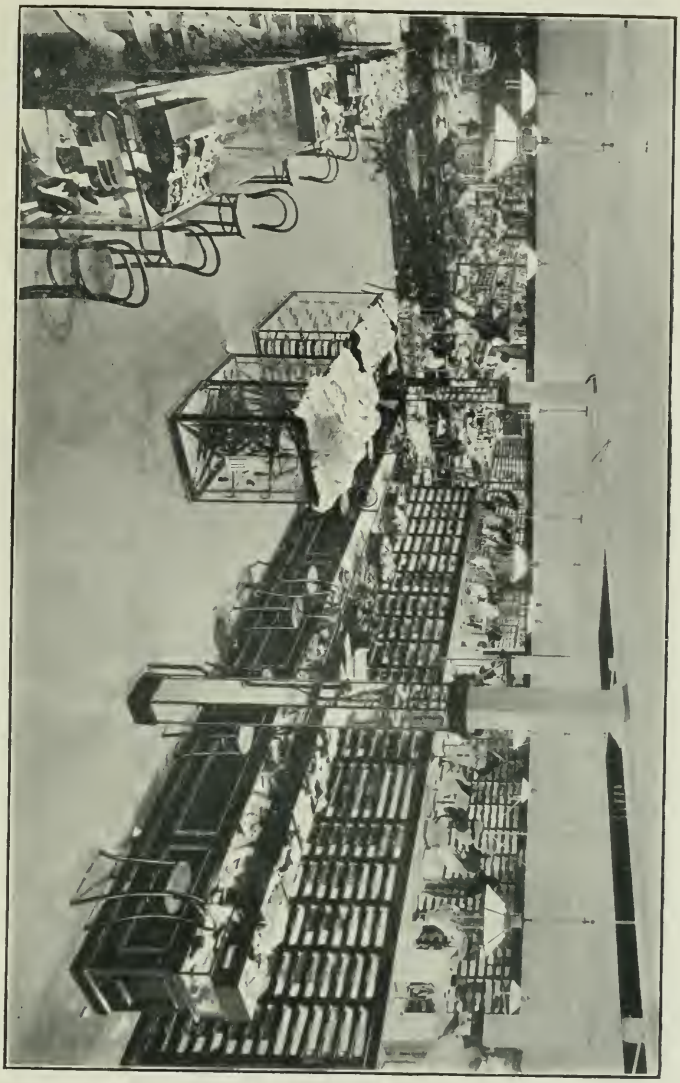
100 to 135 volts.
  10 to 60 watts, from 2s. 6d. to 2s. 2d.
200 to 260 volts
  30 to 60 watts, from 3s. to 2s. 8d.
200 to 260 volts.
  20 watts, from 3s. 3d. to 2s. 11d.
  15 watts, from 3s. 6d. to 3s. 3d.
100 to 260 volts.
  100 watts, from 4s. 9d. to 4s. 3d.
  200 watts, from 9s. to 8s. 6d.
  300 to 400 watts, from 17s. to 16s.

Messrs. Siemens Bros. are likewise making substantial reductions in the prices of Wotan lamps, and some types of Tantalum lamps will also be cheaper in future.

It is hoped that this diminution in price, by cheapening the cost of light and leading to a more generous standard of illumination, will be of benefit to the industry.

MAZDA LAMPS FOR PHOTOGRAPHIC PURPOSES.

We understand from the **British Thomson-Houston Co.** (Mazda House, 77, Upper Thames Street, London, E.C.) that the Mazda lamps are now being used for photographic work, small six-volt concentrated filament lamps being frequently used with a parabolic reflector. These lamps are operated at about 10—20 per cent. over their normal voltage, producing a very white light and giving an illumination which enables quite a short photographic exposure to be made.



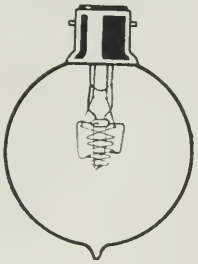
Keith High Pressure Lamps installed in a large Drapery Establishment. The mantles are completely screened from the eye by hexagonal opal shades, which direct the light down on the counters.

KEITH HIGH PRESSURE LAMPS.

We have received from **Messrs. James Keith & Blackman, Ltd.** (27, Farringdon Avenue, London, E.C.), some booklets describing the application of the high pressure lamps of this firm in various trades. Illustrations are given of various large premises, including a general engineering shop and motor-car works. A second publication describes the use of the system in the drapery and clothing establishments. It is interesting to note that this high pressure system is recommended for drapery establishments on the ground that the spectrum of the light is well adapted for colour matching processes.

MAZDA LAMPS FOR MOTOR-CAR HEADLIGHTS.

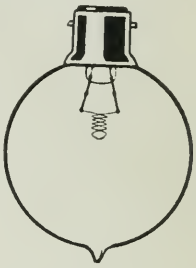
The coming of the motor-car has entirely altered the popular conception of vehicle lighting. The greater speed of modern traffic demands a headlight which will strongly illuminate the road in front for several hundred yards.



Mazda Headlight lamp 32 candle power 12 volts, with helical coil filament.

Much ingenuity has been expended in the design of electrical headlights.

The chief difficulty here is in finding a filament that can be compressed within very small dimensions so as to form what is optically a "point of light."



Mazda Headlight lamp, 25 candle-power 6 volts, with helical coil filament.

The two illustrations show small lamps of this kind developed by the British Thomson-Houston Co. Ltd.

TO THE LIGHTING INDUSTRY.

[We invite firms interested in lighting appliances to send us particulars of new apparatus, lamps and fixtures, and especially interesting lighting installations for notice in our Trade Topics columns.

The "Illuminating Engineer," being published on the first of each month, cannot devote much space to information that has already been widely circulated in the technical press, but new and exclusive information will receive special attention. Matter for inclusion in the next number should reach us by the 20th of the month.—Ed.]

EDUCATIONAL NOTICES.

THE MANCHESTER SCHOOL OF TECHNOLOGY.

The journal containing the record of researches conducted by the staff and students during the past year is a bulky volume containing close on 300 pages. The subjects dealt with cover a wide range of topics, including cutting tools, rail corrugation, colloidal solutions, &c. We notice two papers dealing with light. Mr. W. Harrison discusses the effect of light on colouring matters, and Prof. W. W. Haldane Gee contributes a paper on the physical and chemical actions of light. An important question touched on by the former is the effect of ultra-violet rays on dyed materials, and a table is given comparing sunlight, mercury lamps, and radium emanations.

We have also before us the prospectus for the session 1913-14. A considerable number of highly specialised work is evidently carried out, and we are rather surprised that more attention is not given to illuminating engineering.

KING'S COLLEGE, LONDON.

Prospectus of the Faculty of Engineering for 1913-1914. Special advanced lectures and courses will take place during the present month. These include Electric Locomotives, by Mr. F. Lydall; Control Gear for Motors and Electric Circuits, by Mr. C. H. Wordingham; and Thermodynamics, by Mr. James Swinburne.

The fee for each course of lectures will be one guinea.

WESTMINSTER TECHNICAL INSTITUTE.

Prospectus for 1913-1914. A special feature is the series of evening classes in civil and gas engineering, heating and ventilation, architecture and construction, &c. Classes started on September 22nd.

BATTERSEA POLYTECHNIC.

Courses of Electrical Engineering (Prof. A. W. Ashton, D.Sc., M.I.E.E.), commencing September 29th, 1913. We note that the course includes a series of lectures on Electric Lighting and Illumination, to take place on Fridays, 8.30—9.30.

REVIEW OF THE TECHNICAL PRESS.

ILLUMINATION AND PHOTOMETRY.

Dr. Louis Bell (*Elec. World*, August 23rd) has a word to say about **London street lighting.** The chief thing that struck him during his recent visit was the extreme variety; but many of the individual examples were very good. The *Elec. World* has also been comparing the British and American investigations on the **street lighting specification.** The chief points under discussion seem to be:—

(*a*) whether average or minimum illumination should be measured;
(*b*) whether uniformity of illumination is, or is not, highly essential.

A contribution by L. U. James (*Elec. Rev. and Western Electrician*, September 6th) contains some good photographs of **indirect and semi-indirect lighting** installations. One of the methods shown—the use of standard lamps on pedestals, which direct most of the light upward but also serve for local lighting—is distinctly novel.

Finally, reference may be made to a contribution by G. H. Stickney and A. L. Powell (*Elec. World*, September 6th) on **Reflectors.** Comparative data are given for a variety of types, and the article is concluded by a list, in order of importance of the chief requirements, (*a*) from the practical, (*b*) from the decorative standpoints. It is striking to notice that in both cases the authors place avoidance of glare *first* and cost *last*.

ELECTRIC LIGHTING.

In the Electric Lighting section, the "0·5 watt per candle" lamp is still the chief subject of interest. The comparative merits of tungsten and arc lamps are treated on in a long article by Schmidt (*Z. f. B.*, September 20th); the greater part of this, however, is devoted to technical details.

Licht und Lampe (September 11th) has an illustrated article on the **Dussaud process** of overrunning small c.p. tungsten lamps on an intermittent current. The writer comes to the conclusion that the most hopeful applications of the process are mainly in connection with special work—cinematograph projection, lighthouse signs, &c.

According to an article by G. Sunden (*E. T. Z.*, August 28th) the **enclosure of an incandescent lamp** within an outer globe raises the temperature considerably and shortens the life. He has, therefore, contrived a form of holder which renders the use of an outer globe unnecessary.

Arc lamps receive attention in two contributions by Heyck (*E. T. Z.*, September 11th) and Högner (*E. T. Z.*, August 21st). The former discusses **double and multiple electrode flame arcs**, which he divides into three classes: (*a*) those in which two pairs of carbons are in use simultaneously, or rather in such a way that from time to time the arc is transferred from one pair of electrodes to another pair; (*b*) those providing for the automatic replacement of one pair of carbons as soon as it is used up; and (*c*) those in which the last process can be continued and a large number of electrodes replaced (magazine lamps). He describes a new form of flame arc of the double carbon variety which will burn for 36 hours without attention, and presents some curves to show the steadiness of burning.

P. Högner describes the "**Dia**" **enclosed flame arc,** having vertical carbons. The lamp appears to have a good form of polar curve for street lighting, and the author presents a series of curves and tables showing the effects of spacing these lamps in various ways. The consumption is stated to be about 0·2—0·24 watts per H.K. with a clear globe

GAS LIGHTING.

The chief topic of interest in the gas journals this month is the National Gas Exhibition. There has also been much discussion on the Aisgill train disaster, and it is contended that the fact of gas lighting being used in the carriages had nothing to do with the fire following the collision.

Among other articles in the English papers we notice a contribution in the *Gas World* (September 20th) comparing the results from **high-pressure and low pressure lighting in shops.** The polar curves, and diagrams of horizontal illumination from two typical high-pressure and low-pressure lamps are presented, and it is shown that substantially the same results are obtained for a given consumption of gas. It appears therefore that where only a moderate intensity is needed, the competition between high and low pressure has now become very keen.

A paper by A. Docking, read before the Irish Gas Association, is reproduced in the technical press. The author describes the "Selas" system of gas lighting. This utilises a mixture of $1\frac{1}{2}$–2 of air with 1 of gas at a pressure of about 10 ins. It is claimed that about 50 c.p. per cubic ft. can be obtained in this way.

Among German papers we note that by Hanyzer (*Journal für Gasbeleuchtung*, September 20th), on the **distance control in indoor lighting.** For many purposes—*e.g.*, on staircases, for controlling high lamps in halls, churches, &c., and in hotels, distance control would be very beneficial and, the author suggests, would gain consumers who would otherwise take up electric light.

List of References:—

Illumination and Photometry.

Bell, L. London's Transportation and Lighting (*Elec. World*, August 23rd.)

Editorial. Efficiency of the Eye under different systems of lighting—Municipal Street Lighting in Chicago (*Elec. Rev. and West. Electrician*, September 6th).
Protecting the Eyes of the Public (*Elec. World*, August 16th).
Indirect Car Lighting (*Elec. World*, August 16th).
British and American Street Lighting Specifications (*Elec. World*, August 23rd).
The Advance in Illuminating Engineering (*Elec. World*, September 13th).
The International Illumination Commission (*Elec. World*, September 13th).

James, L. U. Some Interesting Installations of Indirect Lighting (*Elec. Rev. and West. Electrician*, September 6th, 1913).

Spillmann, H. C. Illumination for Industrial Plants (*Elec. Rev. and West. Elec.*, September 6th).

Stickney, G. H., and Powell, A. L. Effectiveness of Reflectors. (*Elec. World*, September 6th).

Webb, W. The Importance of Light in Industrial Occupations (*Am. Gaslight Jr.*, September 8th).
Intensified Lighting of Business Thoroughfares (*Elec. World*, September 6th).
Public Street Lighting in Chicago (*Elec. Rev. and West. Electrician*, September 6th).
The Joint Meeting of the Fourth International Congress on School Hygiene and the Illuminating Engineering Society (U.S.A.) (*Elec. Rev. and West. Electrician*, September 6th; *Elec. World*, September 6th).
The International Commission on Illumination (*Elec. World*, September 13th; *G. W.*, September 6th; *E. T. Z.*, September 18th; *J. G. L.*, September 2nd, 9th).

Electric Lighting.

Editorial. Progress in Incandescent Lamps (*Elec. World*, August 30th).
The Tungsten Lamp Outlook—Arc-lamp Improvements (*Elec. World*, September 6th).

Heyck. Doppelbogenlampen (*E. T. Z.*, September 11th).

Högner, P. Dia-Bogenlampe (*E. T. Z.*, August 21st, see also *Z. f. B.*, August 20th).

Schmidt, J. Die Metallfadenlampe, Kontra Effektkohlenbogenlampe, und die Doppelkohlenflammenbogenlampe (*Z. f. B.*, August 30th, September 20th).

Sunden, G. The Effect of Outer Globes on Life of Metal Filament Lamps (*E. T. Z.*, August 28th, *Elec. Rev.*, September 19th).
Das Dussaudlicht (*L. u. L.*, September 11th).
An Electrically Lighted Tennis Court (*Elec. World*, August 23rd).
Bogenlampen u. Pressgas für Strassenbeleuchtung (*E. T. Z.*, September 11th).
Electric Train Lighting and the Aisgill Disaster (*Elec. Rev.*, September 19th).

Gas, Oil, Acetylene Lighting.

Docking, A. "Selas" System of Gas Lighting (*G. W.*, August 16th; *J. G. L.*, August 19th).

Editorial. Doctors and Electric Lighting—"Selas" Gas Lighting (*J. G. L.*, August 19th).
Gas and the Midland Disaster (*J. G. L.*, September 9th).

Hanyzer, . Die wirtschaftliche Beleuchtung der Gasfernzündung für Innenbeleuchtung, &c. (*J. f. G.*, September 20th).

Othmer, E. Gas u. Elektricität im Lichte der Volkswirtschaft (*J. f. G.*, August 23rd).
High Pressure *v.* Low Pressure for Shop Lighting (*G. W.*, September 20th).
Oil Gas and its Manufacture (*J. G. L.*, September 2nd).
The Improved "Ukay" Lamp (*J. G. L.*, September 2nd).
A New Mannesmann Lamp (*J. G. L.*, September 2nd).
The "Newborn" High Power Lamp (*J. G. L.*, September 2nd).
Novelties of the New Inverted Gaslight Co. (*J. G. L.*, September 16th).

CONTRACTIONS USED.

Elek. u. Masch.—*Elektrotechnik und Maschinenbau.*
E. T. Z.—*Elektrotechnische Zeitschrift.*
J. f. G.—*Journal für Gasbeleuchtung.*
L. u. L.—*Licht und Lampe.*
Z. f. B.—*Zeitschrift für Beleuchtungswesen.*

EFFICIENCY.

The wonderful reflecting surface of "Superlux" Glassware makes it the most efficient glass reflector extant. It is a new and exclusive discovery.

List No G 1727 post free on request

CLEANLINESS

No glass reflector on the market collects so little dust. This is due to its being perfectly smooth and round and having no grooves either large or small upon its surface.

"Superlux"
GIVES PERFECT LIGHT

IN EVERY SINGLE ATTRIBUTE—the very best.

VENTILATION.

The suspension of the glass reflectors is by ordinary gallery, which is the only way efficient ventilation can be provided for. Enhanced appearance and facility in fixing are amongst the many other advantages of this method.

THE
General Electric Co.,
LIMITED,
Head Office—
67, QUEEN VICTORIA ST.,
LONDON, E.C.

REVIEWS OF BOOKS.

Light, Radiation and Illumination. By Paul Högner. Translated by Justus Eck. 1913. (*Electrician Printing and Publishing Co., Salisbury Court, Fleet Street, London,* 88 *pp.*)

But a few months ago we were noticing a translation of Dr. Bloch's well-known work by Prof. W. C. Clinton. Now another member of the Illuminating Engineering Society, Mr. Justus Eck, has brought Dr. Högner's more recent work within the grasp of English readers.

The book is devoted mainly to illuminating engineering calculations. In the first chapter the author works out the illumination from sources or illuminated surfaces of various shapes (planes, rods, spheres, &c.) and develops the conception of luminous flux, and shows how mean spherical candle-power is graphically determined from the polar curve.

We turn next to the calculation of illumination. The well-known formula is given enabling the horizontal illumination from a lamp at a given height to be worked out, and it is shown how the joint effect of ten lamps can be determined. At a somewhat later stage in the book the mapping out of illumination on large horizontal areas is taken up. The author explains the use of contour curves and describes several special methods that he has himself devised for determining mean illumination values.

A section of special interest is that dealing with ceiling radiation, where some data for the calculation of the effect of indirect lighting are given. In the higher branches of design—in dealing with very original methods of lighting especially—a knowledge of such data will often stand the illuminating engineer in good stead.

For the rest it only remains to be said that the book is provided with many useful tables, that the diagrams are clear, and the style concise. Within the 88 pages of the book is packed away much useful information, and we may congratulate Mr. Eck on placing it at the disposal of English readers.

School Hygiene. By Edward R. Shaw, Professor of the Institute of Pedagogy, New York University, 1911. (*Macmillan and Co., London,* 260 *pages.*)

The greater part of this little book is devoted to general hygiene, the first chapter on the schoolroom being perhaps the most interesting to lighting engineers.

The natural lighting of the schoolroom receives about twenty pages. The author comments on the extraordinary difficulty of measuring the illumination—though, perhaps, a fuller knowledge of the improvements in illumination photometers during the last few years might lead him to modify this view.

He suggests that in a well-designed classroom a minimum of 15 sq. ft. floor area and 200 cubic ft. of air space per pupil should be allowed. Window area should be one-quarter to one-sixth of the floor space and *high* windows are preferable. The minimum daylight illumination on the most unfavourably situated desk should not be less than 50 metre-candles (about 5 ft.-candles). There is unanimity that light may enter from the left, but opinion is divided as to whether there should be windows in the rear of the room.

The remaining chapters of the book contain useful information on the general design of buildings, situation, heating and ventilation, sanitation, furniture, &c. There are also special sections on handwriting and the chief diseases of interest to the school officer. A few words are also said on the subject of artificial lighting. We think that, in view of the work recently carried out on this subject, a special chapter might well be given up to it in a subsequent edition.

One feature of this book deserves commendation—the use of mat paper and large type for the text, illustrations being printed on inserted art paper. Authorities insist upon the desirability of such conditions in books for school use, and it is quite right that they should be observed in a work on school hygiene.

INDEX, October, 1913.

		PAGE.
Daylight, Imitation of	Dr. H. E. Ives	510
Editorial	L. Gaster	487
Exhibition Halls, Novel Method of Lighting	R. F. Pierce	505
Illuminating Engineering, Short Notes on	.. ..	513
International Commission on Illumination, The	.. ..	491
International Congress on School Hygiene	.. ..	495
International Electrotechnical Commission, The	.. ..	494
Lawn Tennis Court, Electric Lighting of a	.. ..	502
National Gas Exhibition, The	.. ..	504
Oriental Restaurant, Lighting of a ..	.. ..	512
Review of the Technical Press	.. ..	521
Reviews of Books	.. ..	524
Schoolrooms, Lighting of	Dr. T. Meredith Young ..	498
Trade Topics	.. ..	515

OTHER PUBLICATIONS RECEIVED.*

New Books.

Nouveau Guide Pratique de l'Usager de l'Acétylène (Office Central de l'Acétylène, Paris, 1913.)

———

Licht und Beleuchtung. By Dr. R. Ehrig. (Wm. Engelmann, Leipzig, 1913.)

———

Die Beleuchtung von Eisenbahn-Personenwagen. By Max Büttner. (Julius Springer, Berlin, 1912.)

———

Die Verwendung der seltenen Erden. By Dr. C. R. Böhm. (Veit and Comp., Leipzig, 1913.)

———

Industrial Illumination. By C. E. Clewell. (McGraw Publishing Co., U.S.A.; Hill and Co., Bouverie Street, London.)

———

Journals and Smaller Publications.

International Congress on the Prevention of Accidents and on Industrial Hygiene. (Milan. 1912.)

We have received from Sig. Francesco Massarelli, the General Secretary, Vols. I. and II., containing the proceedings at the above Congress. The volumes are fully illustrated, and contain a record of much useful work.

———

Official Guide and Programme to the National Gas Congress and Exhibition. As we go to press we receive the official guide to the above Exhibition. This contains full particulars of the Conferences and Popular Lectures, and the arrangement of the various sections is very neatly and clearly explained. The whole get-up is an excellent testimony to the efforts of the chairman of the Editorial Committee. Mrs. M. A. Cloudesley Brereton.

———

Souvenir Programme of the Seventh Annual Convention of the Illuminating Engineering Society (U.S.A.) to be held at Pittsburgh, September 22nd—25th, 1913.

———

"Industrial Lighting" (an illustrated pamphlet issued by the British Thomson-Houston Co.), and "Lighting News," the second number of the small booklet of this name issued by this firm.

———

"The World" for September 30th contains a special Lighting and Heating Supplement. Reference is made to the good work accomplished by the Illuminating Engineering Society in this country, and portraits are reproduced of several authorities closely associated with the movement.

* To some of these publications we hope to refer more fully shortly.

THE

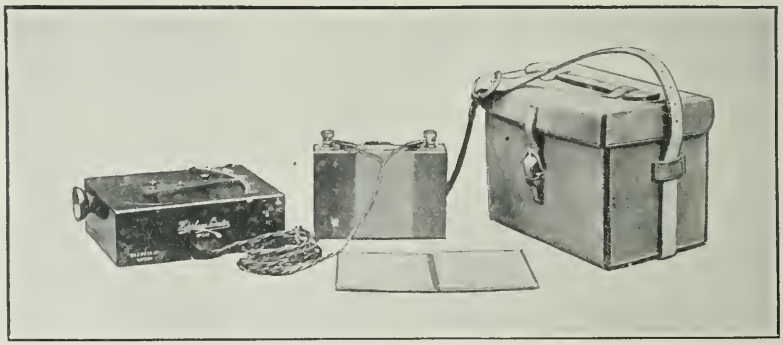
Holophane Lumeter.

THE simple, portable, and accurate apparatus for measuring illumination, surface-brightness, or reflecting power.

Can be carried from place to place with the ease of a small hand camera.

Dimensions only $5\frac{3}{4}$ in. × $4\frac{1}{2}$ in. × $1\frac{3}{4}$ in.; case and accumulators supplied.

Measurements from 0·01 to 2000 foot-candles can be made.



Showing general appearance of new model of Holophane Lumeter.
(Dimensions: $5\frac{3}{4}$ in. × $4\frac{1}{2}$ in. × $1\frac{3}{4}$ in.)

The Holophane Lumeter is of value not only to lighting engineers, but to architects, medical officers, factory inspectors, photographers, and many others.

Among the users of this instrument may be mentioned:—

The House of Commons, The Home Office (Factory Dept.), The London County Council, General Post Office, Great Western Railway, L. & S.W. Railway, Underground Railways, The Gas Light & Coke Co., St. James and Pall Mall Electric Supply Co., The Union Electric Co., The British Thomson-Houston Co., &c., &c.

For all particulars apply to

HOLOPHANE, LTD.,

12, Carteret St., Queen Anne's Gate, S.W.

The ILLUMINATING ENGINEER
ELECTRICITY · ACETYLENE · OIL · GAS
Edited by LEON · GASTER

THE JOURNAL OF SCIENTIFIC
ILLUMINATION.
OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London, 1909.)
ILLUMINATING ENGINEERING PUBLISHING COMPANY, LTD.,
32, VICTORIA STREET, LONDON, S.W.
Tel. No. 5215 Victoria.

EDITORIAL.

The National Gas Exhibition.

In this number we are presenting a special account of the National Gas Exhibition, which has just terminated at Shepherd's Bush. Readers will find on pages 539-571 a summary of the chief papers on illumination read at the Conferences (with the exception of the Conference of Manufacturers on October 29th, with which we mean to deal in our next number), and a general description of the exhibits. Restrictions of space prevent our dealing with the subject as fully as we should have liked, but we have endeavoured to bring before our readers the salient features. The occasion has been an exceedingly important one to the gas industry, and there were several respects in which it was of more than ordinary interest to the general public.

There are two points that may be singled out for special reference. In the first case the arrangement of the Exhibition was decidedly novel. In place of a series of stalls by individual exhibitors in which goods of the same kind are constantly repeated, we have here a collective exhibit.

Appliances of the same kind supplied by various firms have been assembled together and the aim has been to present to the public the general progress in the application of gas rather than to follow the customary trade conception of displaying the wares of certain exhibitors. There can be no question that from the standpoint of the public the method adopted is the more convenient and attractive one.

The task of organising this representative collection of exhibits by so many different manufacturers must have been a difficult one, and it is not surprising that in a few cases there was some confusion between the exhibition of lamps *as* lamps, and their use to produce a certain illuminating effect. But in the circumstances the task of devising exhibits to illustrate certain principles of illumination was well performed.

The second point on which we wish to dwell is the statesmanlike policy of incorporating with the Exhibition, conferences on subjects of general interest. In his introductory remarks at one of these conferences, Mr. Goodenough was careful to explain that the platform had been provided for genuine discussion of lighting problems independent of the nature of the illuminants. The influential patronage given to the conferences and the fact that such eminent men consented to preside is an indication of the wisdom of this policy. The result has been that the proceedings at the conferences have been very widely reported in the Press, and attention has been drawn to the Exhibition in many quarters that could not have been reached by any other means.

The Illuminating Engineering Society was given an excellent opportunity of bringing forward its aims and objects and the fact that the Conferences dealing with lighting were all given up to the discussion of illumination in its broader aspects, rather than to the technicalities of gas appliances was a justification of the patronage given by the Society to the Exhibition.

The broadness of conception that characterised the whole Exhibition was well illustrated in the inaugural address of Sir Corbet Woodall, when he stated that this was a " pro-gas " but *not* an " anti-electric " Exhibition. Sir Corbet also expressed the belief that there was ample room for gas and electricity to work side by side ; and Lord Rayleigh, when presiding at the Conference on Scientific Illumination, pointed out that the work of the Illuminating Engineering Society has shown how many were the subjects on which representatives of the two industries could work together on parallel lines.

With such authoritative expressions of opinion in favour of a " live and let live " policy in matters of illumination, we hope that the old controversial methods will gradually give way to a more enlightened policy of mutual assistance.

In passing, we should like to add that the example set at this Exhibition might well be imitated by the electrical industry, and we hope

that when the time comes to organise a similar exhibition showing the general advance in electricity in the service of man, a similar policy will be pursued.

The vast ramifications of the gas industry, on which Sir Corbet also laid stress ; the huge amount of capital, now amounting to over £140,000,000, invested in it ; and the many thousands who gain their livelihood more or less directly through the manufacture of gas, are all, to our mind, reasons for desiring its welfare. A serious check to the industry would be a calamity which electrical interests would be the first to feel, and there is no valid reason why representatives of either industry should regret the prosperity of the other.

In conclusion, a word of praise should be given to those who have worked so hard to make the Exhibition a success. Special reference should be made to the energy and tactful supervision of the Chairman of the Executive Committee, Mr. F. W. Goodenough, and to the very able way in which Mrs. Cloudesley Brereton (also a member of the Illuminating Engineering Society) organised the editorial arrangements.

Illumination and Education.

At the Conference of Educationists on October 11th the subject of School Lighting was again to the fore. We find in the sympathetic remarks of the Chairman, Sir George Kekewich, and in the other speeches delivered on this occasion a general recognition that good lighting in the school is essential in the interests of the eyesight of the children, and that, to quote the remarks of Mr. Goodenough, "it is impossible to educate a child properly in an ill-lighted, ill-ventilated, or ill-warmed school."

There was another argument in favour of good illumination, which seemed to impress those present, and which had not been stated fully previously, namely, the value of good illumination in a school *as an example* to the children. It was pointed out that if children in a school are accustomed to slovenly methods of lighting, gloomy surroundings, badly placed lamps, and imperfectly screened fittings, they will afterwards view with indifference similar defects in their own homes ; thus the evil of bad lighting tends to be perpetuated. Now one of the chief objects of education in the present day is surely to train the children in cleanly and hygienic habits. It therefore seems to be of the utmost importance that they should learn early how essential from the hygienic standpoint is good illumination.

In short the claims of good lighting in the school are now no longer contested. We venture to hope that Sir George Kekewich, who was so long associated with the Board of Education, will influence that body to give its support to an official and exhaustive inquiry into the lighting conditions in schools, and their effect on health and sight. The Illuminating Engineering Society, through the work of its committees, has carried the subject to a certain point, and won general approval for

the work so far done. We believe that the time is now ripe for the subject to be taken up by a body capable of organising a really comprehensive inquiry and giving effect to the conclusions arrived at. The matter is one of national importance and should not be left to the efforts of a few devoted enthusiasts who, however great their goodwill, naturally cannot be expected to give up their time indefinitely to unpaid labour of this kind. The time has come when the Board of Education should be approached and asked to give encouragement to these researches, and the Illuminating Engineering Society will be only too glad to co-operate and place their experience at the Board's disposal.

Office Lighting and Eyesight of Clerks.

At the conference of manufacturers on October 29th several papers were presented showing the vital importance of good lighting in the factory, and this subject is certainly exciting a great deal of comment just now.

But there is another question, the lighting of offices, which ought surely to be considered at the same time, and is in many respects quite as important. Dr. Meredith Young in the course of his paper on "Light and Sight" remarked: "It is a pity that some information is not available as to the amount of defective vision existing among that large section of the business population represented by clerks. This large body of workers seems to have escaped the eye of the Home Office and of the Legislature, and in many other matters besides that of lighting and heating demands attention."

In such an exacting occupation it is particularly necessary that the illumination should be good. We have heard of cases of clerks whose eyesight has been ruined by their occupation, and who, when they approached their employers, were unable to secure any redress. Yet it is surely as reprehensible for an employer, by neglecting the lighting conditions, to injure the eyesight of his employees as it would be for a manager of a factory, by neglecting to make proper provision for cleanliness, to foster cases of poisoning in dangerous trades.

In many instances poor lighting conditions in banks and offices are the result of want of thought and "makeshift" devices. When a new lamp arrives it is substituted in the old fittings without the thought occurring that what was suitable twenty or thirty or more years ago, is no longer desirable to-day. At the present time there is no reason why the best method of lighting, as far as present experience goes, should not be insisted upon—the more so because banks and large offices are conducted by wealthy people who can afford to take broad views and should recognise that poor lighting is a frequent cause of errors and spoiled work, and is invariably inefficient and uneconomical.

LEON GASTER.

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of "The Illuminating Engineer."

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

THE SEVENTH ANNUAL CONVENTION OF THE AMERICAN ILLUMINATING ENGINEERING SOCIETY.

(Held in Pittsburg, September 22nd—25th, 1913.)

The arrangements for the Convention seem to have been exceptionally complete this year. The Souvenir Programme issued to members was an attractively got up publication. Several of the meetings were held in the Soldiers' Memorial Hall, the decorative lighting of which has been previously described in these columns.*

In this number we can only give a rough outline of the contents of the papers, a complete list of which will be found at the end of this article.

General Progress.

The report of the Committee on Progress has this year been extended considerably. Special sections are devoted to electric incandescent, arc and vacuum tube lamps; gas lighting; acetylene and other systems; photometry; ophthalmology; progress of the Illuminating Engineering Societies, and co-operation with other bodies; indirect and semi-indirect lighting; street lighting; fixtures; globes and reflectors; physics; photography in illuminating engineering and illumination measurements and calculations. References are given to many of the chief papers that have appeared in Europe and in the United States. Altogether it is a useful publication, and we propose to reproduce it shortly in this journal.

IMPROVEMENTS IN ELECTRIC INCANDESCENT LAMPS.

Several papers were read on the above subject. Mr. J. W. Howell pointed out the great accuracy now secured in the rating of lamps. It is the present aim of lamp makers to secure a commercial life of 1,000 hours in all standard tungsten lamps. A compromise is necessary between thin filaments which are apt to break mechanically and thick filaments which are apt to blacken the bulb.

Reference was also made to the new 0·5-watt per candle lamp burning in an atmosphere of nitrogen. The presence of this gas is apt to cool the filament. Comparatively thick wire is therefore desirable and only high candle-power lamps will first be supplied. Mr. Howell showed a 110-volt 20-ampère lamp, giving about 5,000 c.p.; this is the largest output ever obtained in a single incandescent unit. He believed, however, that incandescent lamps giving even 10,000 c.p. could be produced if a demand arose for such extremely powerful lamps as this.

* Illum. Eng. Lond., Vol. VI., 1911, pp. 197, 261.

A paper was also read by Mr. W. Harrison and Mr. E. J. Edwards on tungsten filaments. The authors declared that since 1908 the strength of tungsten filaments had increased quite 300 per cent.; and that the strength of drawn wire had increased 40 per cent. since 1911.

Reference was made to the use of chemicals in the bulbs of lamps in order to reduce the blackening effect. This has made it possible to reduce the size of lamps. Another striking development has been the introduction of helical filaments wound in a small space. These should be specially useful for optical purposes where a highly concentrated light is required. It is expected that such lamps will bring about a considerable change in the design of shades and reflectors; especially those intended to give a highly concentrated light.

T. H. Amrine describes some experiments on the **cooling effect of leading-in wires.** This is a matter of some practical consequence, and affects the efficiency of metal filament lamps materially. For example, it is possible to have two lamps of the same voltage and c.p., and with filaments of the same diameter but differing in length by as much as 30 per cent.

QUARTZ TUBE MERCURY LIGHT.

W. A. D. Evans read a paper on the **Mercury Vapour Quartz Lamp.** The author gave curves illustrating the relation between watts per candle and pressure in the tube and diagrams showing how the leading-in wires are sealed into the tube. A marked step forward has been the use of a quality of glass which enables a tungsten wire to be melted in, thus making a better joint than the grinding-in process. Illustrations of a very varied selection of factories, foundries, &c., lighted by quartz tube lamps are given. The specific consumption varied from 0·11 to 0·69 watts per square foot. In conclusion, the author gives an account of the use of quartz tubes for pathological and other purposes. The number of industries in which **ultra-violet rays** are now used is quite remarkable, for example, the fixation of patent leather, the bleaching of flour, the treatment of oils, paraffin, &c., and the testing of the permanency of colours. It is stated that for testing dyed fabrics the lamp will accomplish in a few hours what would require 72 hours by daylight.

NEON TUBE LIGHTING.

A paper by Mons. George Claude was read, describing the novel system invented by him of lighting with **vapour tubes containing Neon.**

The author explained how essential it was to have a pure gas free from mixture with hydrogen, and how he had succeeded in avoiding the absorption of gas by the electrodes. With tubes 6 metres long a life of 1,000 to 1,200 hours can usually be obtained. The installation at the Grand Palais at the Champs Elysées in Paris, the St. Ouen Church at Rouen, &c., have been lighted by Neon tubes on festive occasions, and the red colour is considered to have a great value for decorative and spectacular purposes. On the other hand, for ordinary lighting the colour is something of a drawback, and the author suggests that a fairly white light could be obtained by a combination of Neon tubes (which contain only red rays) with Mercury vapour lamps in which only yellow-green and blue rays were present.

SHADES AND REFLECTORS.

Mr. V. R. Lansingh contributed a paper analysing the qualities of various types of glassware and containing illustrations of new types of white glass and Holophane prismatic globes. In each case the polar curve is given. In summarising his tests, the author points out that glassware may be divided into two distinct classes—one purely transmitting and diffusing such as ground glass and opal glass, &c., and prismatic glass, where the principle of direct reflection is employed.

The last-named type of glassware is most effective in altering the distribution of light from the source.

RESEARCHES ON PHOTOMETRY.

E. C. Crittenden and A. H. Taylor presented a paper on **the Pentane Lamp.** Detailed instructions are given with regard to the preparation and use of these lamps for standard purposes, and references are included to all the chief papers published on this subject. One

of the most interesting things in the paper is a chart showing the different conditions as regards percentage of the water vapour in various parts of the United States. Whereas in New Orleans the water vapour present in a cubic metre of air varies from about 11—28 meters during the course of the year the corresponding variation at San Francisco is only from about 10—13.

It may be noted that in Boston the average percentage departure of a Pentane lamp from its normal value is about —1·1 per cent. but in New Orleans is +6·3 per cent. Other matters dealt with in the paper include the testing of pentane for use with the lamp, and the effect of ventilation and vitiation of the air on the light. The figures given show that measurements of this lamp can now be made with a high degree of accuracy.

An interesting paper by E. J. Edwards and W. Harrison deals with the **accuracy of photometry.** The first part of the paper analyses the chief sources of error. It is interesting to note that the average deviation of readings is given as 0·4 per cent. in the Lummer-Brodhun instrument as compared with 1·4 per cent. for the Bunsen.

The authors take the view that the errors due to parallelism of rays (" searchlight effect ") are negligible, if the experiments are rightly conducted.

A useful section of the paper is that discussing **errors in illumination photometers** due to departure of test-plates from the cosine law. The average error at an angle of 45° was found to be over 10 per cent., and the authors consider that results when testing an average installation are about 12 per cent. low.

The final section of the paper deals with **methods of obtaining and recording distribution data.** Many illuminating engineers have experienced the difficulty that if polar curves of reflectors giving a widely different distribution of light are plotted strictly to scale, the distinction between their properties is not apparent to the non-technical man.

The authors propose that all such curves should be plotted on a " thousand lumen " basis, and tables and charts are given showing how such data are conveniently presented.

S. L. E. Rose describes the **Illuminating Engineering Laboratory** of the General Electric Co., which seems to be very completely equipped. A plan is given showing the various sections devoted to the photometry of arc lamps, large gas lamps, life tests of incandescent lamps, colour testing, photography arc, &c. Photometers of the " constant length " and " constant radius " types are used for determining polar curves of light distribution, and Ulbricht spheres of 1 and 2 metres diameter are also used for obtaining data regarding the mean spherical c.p. An interesting section is the photographic department which furnishes the commercial division of the company with day and night views of representative installations and also provides photographs illustrating distinctions between good and bad lighting.

In the Show Room a very practical device is the installation of a series of booths arranged to show the intensity of illumination in steps from $\frac{1}{4}$ up to 20 foot-candles. This gives the non-technical man an idea of what is meant by an illumination of so many foot-candles which a photometric measurement may not convey.

F. K. Richtmyer discusses the **use of the Selenium Cell** in photometry. The experimental difficulties involved in the use of such cells appeared to be considerable, and there are also difficulties arising from the fact that the sensitiveness of the cell to light of different colours is widely different from that of the eye. In addition, an incautious exposure of the cell to a very high illumination (above that for which it is customarily used) would lead to its giving very erratic results.

EFFICIENCY OF THE EYE UNDER VARIOUS SYSTEMS OF LIGHTING.

Dr. C. E. Ferree describes a series of measurements intended to ascertain (a) whether the eye shows a loss of acuteness of vision after three or four hours' work under a given lighting system, and (b) whether there is a progressive loss of efficiency in working for several months or years under any particular system. The problem is a complicated one, and acuteness of vision has to be distinguished from purely muscular or mental fatigue. Experiments were made by observing a

number of test objects, consisting of vertical parallel lines, dots, &c. It is apparently difficult to draw definite conclusions from the author's results, which were subjected to some criticism in the discussion. His chief deduction seems to be that the most important factor for the welfare of the eye is a distribution of illumination, and that the actual amount of light provided is in most cases needlessly high.

LIGHTING INSTALLATIONS OF VARIOUS KINDS.

Quite a variety of papers were presented dealing with various kinds of lighting installations. E. F. Kingsbury describes the **gas lighting of a Sunday School** by some novel methods. Lamps controlled by electro-magnetic means were placed above a diffusing glass ceiling, and the alcoves at the ends of the room were lighted by placing a large semi-circular translucent screen in front of each of the 11 upright burners. The average illumination secured appears to have been about 1 foot-candle, and in view of the nature of the work and the restful effect of the lighting this was considered sufficient.

STREET RAILWAY LIGHTING

is treated by S. G. Hibben. He states that metal filament lamps have entirely replaced carbon filament lamps in the States. The latest device is the use of 94 or 56-watt lamps in conjunction with suitable shades. The glare from a long row of unscreened lights is now considered most objectionable, and the new method is likely to be largely introduced. Besides being more restful and decorative, the cost of lighting with the new units will be exceptionally low.

Diagrams showing the arrangement of lamps and the illumination in the cars are given. It appears that with the old type of carbon filament lamps an average illumination of 2·24 foot-candles was found; with shaded metre filament lamps a higher value of 4·13 foot-candles is provided.

W. S. Kilmer's paper on **Hospital Lights** may be divided into two branches: —the lighting of the wards and the provision of special lamps for operating tables, &c. For ward lighting the author considers indirect and semi-indirect methods to be beneficial, the lamps being usually fitted down the centre of the room. In the illustration given by the author local brackets are also placed over the beds, but presumably these are only turned on when the doctor wishes to examine the patient's condition closely. For the illumination of operating tables small bulb lamps, placed at the focus of parabolic metal reflectors, are largely used. The author also shows some special conical reflectors by which an illumination similar to daylight in intensity and spectrum composition can be provided for microscopes.

A paper by M. H. Flexner and A. O. Dicker on **Factory Lighting** contains a number of arguments in favour of good illumination. A series of calculations are given, showing that good lighting, which has such an important influence on the quality and output of the work, nevertheless forms but a small percentage of the total costs of salaries and upkeep of machinery. For example, from data on a large number of installations, the cost of labour per day works out to 3·5 dollars, and the corresponding cost of light per day is only 0·02 dollars—*i.e.*, about half a per cent. of the cost of labour.

In conclusion the author describes a very interesting experiment being tried by the Commonwealth Ediswan Co. of Chicago. To many consumers the first cost of the installation is thus an important consideration. The company therefore arranges a contract, including charges for rental, maintenance and electricity, so that the customer can pay in instalments for the installation, which ultimately becomes his property.

The paper by R. B. Ely on **Church Lighting** is chiefly interesting as showing the great variety of methods used in churches in the States. Some are lighted by clusters of chandeliers, others by overhead illumination through a diffusing glass ceiling, and others again by cornice lighting.

A modern tendency is the use of illuminated texts round the walls, or even designs in large letters upon the roof of the building. The name of the church is often indicated by an illuminated sign over the porch. Another development is

the use of an illuminated bulletin board on which notices of events are presented.

Seeing how vital it is to the modern church to attract the attention of passers-by and secure their support, the use of such methods would seem to have a certain justification.

In conclusion we may notice a series of three papers devoted to **shop lighting.** J. E. Philbrick deals with shop lighting by gas in a general manner, insisting on the importance of technical information on the subject being placed in the hands of canvassers. H. B. Wheeler deals with **window lighting,** showing various types of reflectors conveniently used in modern shops, and indicates the distribution of light from each. An interesting method employed in the paper is the presentation of diagrams showing the distribution of illumination for the "line of trim." By this phrase is meant the sloping contour from the front of the window to the back along which the goods are mainly arranged and where the light is chiefly needed.

Finally, there is a paper by C. L. Law and A. L. Powell on **decorative store lighting.** The authors try to discriminate between the needs of a variety of shops (devoted to toys, jewellery, millinery, books and curios, &c.). The main argument adopted is that special lighting should be used according to the nature of the trade. Illustrations of a considerable number of shops are given and data of lamps supplied in each case.

PAPERS PRESENTED AT THE CONVENTION :—

Report of the Committee on Progress.
The Evolution of the Lamp. By Roscoe F. Scott.
The Use of Nitrogen at Low Pressure in Tungsten Lamps. By G. M. J. McKay.
Current Developments in Manufacture of Incandescent Lamps. By T. W. Howell.
Some Commercial Aspects of Gas Lighting. By J. E. Philbrick.
Recent Improvements in Incandescent Lamp Manufacture. By Ward Harrison and Evan J. Edwards.
The Cooling Effect of Leading-in Wires upon the Filaments of Tungsten Incandescent Lamps of the Street Series Type. By T. H. Amrine.
The Mercury-Vapour Quartz Lamp. By W. A. D. Evans.
A Lecture on Neon Lighting. By George Claude.
Characteristics of Enclosing Glassware. By Van Rensselaer Lansingh.
Some Theoretical Considerations of Light Production. By W. A. Darrah.
Some Studies in Accuracy of Photometry. By Evan J. Edwards and Ward Harrison.
The Pentane Lamp as a Working Standard. By E. C. Crittenden and A. H. Taylor.
The Photo-Electric Cell in Photometry. By F. K. Richtmyer.
The Illuminating Engineering Laboratory of the General Electric Company. By S. L. E. Rose.
The Efficiency of the Eye under Different Systems of Illumination—The Effect of Variations in Distribution and Intensity. By C. E. Ferree.
The Psychological Values of Light, Shade, Form, and Colour. By Dr. F. Park Lewis.
Experiments in the Illumination of a Sunday-School Room with Gas. By Edwin F. Kingsbury.
Modern Practise in Street Railway Illumination. By S. G. Hibben.
Hospital Lighting. By William S. Kilmer.
Factory Lighting. By M. H. Flexner and A. O. Dicker.
Store Lighting. By J. E. Philbrick.
The Lighting of Show Windows. By H. B. Wheeler.
Distinctive Store Lighting. By Clarence L. Law and A. L. Powell.
Church Lighting. By Robert B. Ely.

A HISTORIC GAVEL FOR THE ILLUMINATING ENGINEERING SOCIETY (U.S.A.).

We observe that at the opening meeting of the American Illuminating Engineering Society on September 23rd, Prof. G. A. Hoadley, on behalf of the Philadelphia section, presented to the Society an interesting chairman's gavel of unique composition and designed to illustrate the progress of illumination from the remote past up to the present day.

The oil lamp is represented by two pieces of iron from a bracket designed by Benjamin Franklin; the incandescent mantle by a vial of the original fluid made in Welsbach's laboratory in 1887; and the arc lamp by a piece of the first electrode used in a magnetite arc in 1903, and a carbon holder used in one of the first lamps designed by Prof. Elihu Thomson. The incandescent lamp is represented by a die used by Mr. Edison in his early experiments with filaments in 1879.

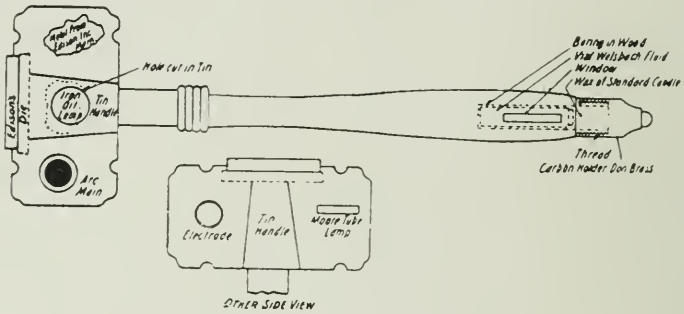


Fig. 1.—Diagram showing constitution of Gavel.

Fig. 2.—General view of Gavel.

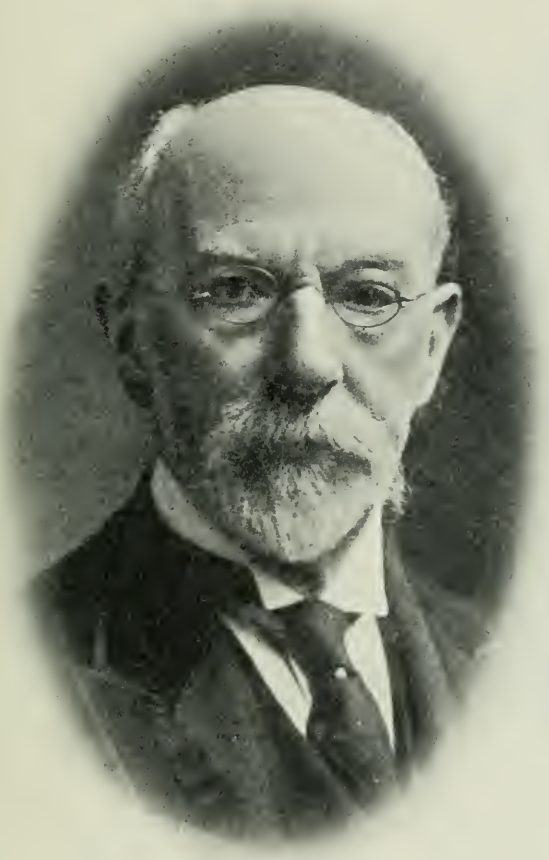
Altogether the design of the gavel seems to be a bright idea. The two accompanying illustrations show how these historic constituent parts are to be arranged.

THE NATIONAL GAS EXHIBITION AND CONGRESS.

(Held at Shepherd's Bush, October 1st—October 31st, 1913.)

The Opening of The Exhibition.

The National Gas Congress and Exhibition was duly opened on October 1st by the Lord Mayor of London in the presence of a very representative gathering of members of the Gas Industry from London and the provinces. A telegram had been despatched tendering the loyal greetings and expressing appreciation of the patronage given to the Exhibition by His Majesty King George and the Queen, and a Royal Message graciously acknowledging the telegram and expressing wishes for the success of the Exhibition was subsequently read out by Sir Corbet Woodall.



Sir Corbet Woodall, D.Sc., M.Inst.C.E.
President of the Exhibition.

In opening the proceedings Sir Corbet Woodall alluded to the wide ramifications of the gas industry, the capital invested in which now exceeds 140 million pounds. He explained how all the sections of the industry were to be represented at the Exhibition, and how the exhibits were to be supplemented by conferences and lectures on many topics.

The Lord Mayor, in returning thanks for the President's welcome, also alluded to the marvellous progress and improvements of recent years in the production and application of gas for illuminating, cooking, heating, industrial and other purposes—matters which were of vital importance to young and old, and to all sections of the public.

Mr. Edward Allen, President of the Institution of Gas Engineers, proposed a vote of thanks to the Lord Mayor and Prof. H. B. Dixon, President of the Society of British Gas Industries, seconded the motion.

At the Inaugural Banquet which followed, an address was delivered by The President (Sir Corbet Woodall), who emphasised the fact that from its very commencement gas had been not a commodity intended mainly for the aristocracy but a practical boon to the general public.

Sir Corbet also expressed the belief that there was room both for gas and electricity,

and that both systems of lighting had their legitimate fields of employment.

"From a luxury of the prosperous middle class, gas has been raised into the status of a necessity of all classes. I need hardly say that this is not an anti-electric, it is a pro-gas exhibition. We recognise that there is room and a place for both gas and electricity in the service of the community. We use electricity for certain purposes in our works; the electrician uses gas largely in his works for the making of cables, dynamos and lamps, while the consumer in many cases uses gas to produce electricity. The presence of so many among us to-day who are at the head of both gas and electricity undertakings is evidence of a community of interests between the two."

Mr. F. W. Goodenough.

Chairman of the Executive Committee of the Exhibition.

Mr. F. W. Goodenough proposed the toast of the Lord Mayor, and recalled that as far back as 1859, the Lord Mayor of London at that time had opened the works of the Great Central Gas Consumers' Company and had addressed the workmen present on the advantages of gas.

In our last number we gave a list of the papers to be read at the Congress and the series of popular lectures taking place each evening during the month of October. A notable element in the Exhibition has been the distinguished patronage it has received from men of high scientific repute, and the proceedings at the various conferences, in particular, have been closely followed both in the daily and technical Press.

Readers will find in recent numbers of the *Journal of Gas Lighting* (to whose courtesy we are indebted for the blocks showing the portraits of Sir Corbet Woodall and Mr. Edward Allen) a detailed account of the proceedings. On pp. 551-570 we give abstracts of the chief papers presented.

Illumination and Education.

The Conference of Educationists was opened on Saturday, October 11th, Sir George Kekewich being in the chair.

Mr. F. W. Goodenough, in expressing a welcome to Sir George and to the readers of the papers, explained that it was the desire of the Executive Committee that impartial information of value to those concerned with education should be presented, and it was in no way desired to use the conferences as a party platform on behalf of gas against any of its competitors.

Sir George Kekewich recalled some of his experiences in examining the ventilation and lighting of schools, and commented on the great progress that had been made in the planning and allotting of adequate window space. But the question of artificial lighting was also of great importance. Excessive brilliancy should be avoided and the lights should be properly shaded.

Prof. S. P. Thompson then read his paper entitled "Some Consideration of the Brightness of Lights." Subsequently, Mr. J. S. Dow, in the unavoidable absence of Mr. Leon Gaster, presented the latter's paper on the "Physiological and Mental Disadvantages of Unscientific Illumination" (see pp. 554-556).

Mr. A. J. Martin, who proposed a vote of thanks to the authors of the papers, laid stress on the importance of adequate illumination rather than lamps of high candle-power. The distribution of illumination was of great importance; yet it was not an easy matter to arrange the lighting of a room containing forty or fifty children so that none of them were exposed to glare. Again the direction from which the light struck the printed page of a book which children were reading, or the sheet on which they were writing, was also of importance. He hoped that the Board of Education would pay special attention to this matter. In particular the Board should obtain the services of inspectors qualified to deal with this aspect of illumination, and should see that the plans of schools fulfilled their requirements.

Mr. F. W. Goodenough, in seconding the vote of thanks, confirmed Prof. Thompson's statement with regard to the necessity of good methods of measurement, and remarked that the eye unaided was a very incomplete photometer.

Mr. Goodenough also laid stress on the desirability of printing on a quality of paper without much shine, and mentioned that an illustrated pamphlet recently reprinted from the *Illuminating Engineer*, and issued by the British Commercial Gas Association, fulfilled the requirements in this respect very well.

Experts showed that it was impossible to work in an ill-ventilated, ill-lighted, or ill-heated schoolroom, and he was glad to hear that this was being brought home to those responsible for school equipment.

Mr. J. G. Clark likewise alluded to the importance of proper spacing of lights. He pointed out that the recommendations already issued by the Illuminating Engineering Society, if conscientiously carried out, would bring about a great improvement in the lighting of schools in this country.

Mr. Edward Allen.

President of the Institution of Gas Engineers.

Mr. P. J. Waldram pointed out that the question of daylight illumination on which not much had been said in the two papers presented, was one of the most important items for the designers of schools, seeing that they were used chiefly in the daytime.

The vote of thanks having been put to the vote and unanimously carried, Prof. Thompson thanked the meeting on behalf of Mr. Gaster himself. He explained that this being a Gas Exhibition, he had naturally devoted attention to artificial lighting. The lighting of large buildings was very frequently carried out in a very haphazard manner. He mentioned a case in which a firm, after inspecting the plans for a building, had merely specified so many lamps for each room, spaced in a uniform manner, without inquiring for what purpose the rooms were to be used. He thought that the subject of lighting should receive special attention in connection with courses of architecture, so that architects, in whose hands the lighting often rested, could be induced to take more interest in illumination.

In the course of the afternoon two papers were read, one by Mrs. Mildred Atkinson on "Cookery in the School," and the other by Messrs. Septimus Warwick and Austen Hall on "The School of the Future."

Subsequently, Mr. Edward Allen proposed a hearty vote of thanks to the authors and dwelt on the importance of bringing home to architects what could be done by modern methods of illumination. The Chairman, in putting the vote, said that he understood that the L.C.C. were paying increased attention to this matter.

Mr. Goodenough next proposed a vote of thanks to Sir George Kekewich for the able and genial manner in which he had presided. The vote was seconded by Mrs. Cloudesley Brereton, who mentioned that she herself had been an official under the Board of Education at the time Sir George Kekewich was secretary. The educational world owed a great deal to men who continue to take an interest in these subjects after having retired. The vote of thanks having been carried the conference closed.

Hygiene of Lighting and Heating.

At the Conference on this subject on October 14th papers were presented by Dr. S. Rideal (see pp. 557-559) and by Dr. Leonard Hill, and by Prof. Vivian Lewes. Dr. Rideal's paper was devoted mainly to an account of the experiments carried out by him some years ago, in which he demonstrated the comparative physiological results in two rooms of equal size, lighted respectively by gas and electricity. Dr. Leonard Hill dealt with the Health Value of Radiant Heat, and described experiments with specially constructed thermometers illustrating the difference in effect of a coal and gas fire. Prof. Vivian Lewes discussed phenomena connected with combustion, and stated that the ideal stove should emit heat in such a manner as to warm the solid objects in the room but leave the air cool for carrying on the functions of the body.

Scientific Illumination.

The first paper on this subject, by Mr. Leon Gaster, summarised the Aims and Objects of the Illuminating Engineering Society. It was followed by papers from Dr. Meredith Young on Light and Sight, and from Mr. Franklin Thorp on the Economy of Efficient Lighting (see pp. 561-570). The titles were aptly chosen so that general principles of illumination, their importance to vision, and their application in the factory were all fully illustrated.

Mr. Goodenough, in introducing the Chairman (Lord Rayleigh), expressed the great appreciation all must feel of Lord Rayleigh having given up some of his valuable time to preside.

The Chairman pointed out that the basis of proper illumination was essentially scientific. It is only through the illumination shed upon objects, and the light reflected from them, that these objects become visible. A thing that is absolutely transparent—that allows light to pass through but reflects none—would, in fully diffused light, be absolutely invisible. Prof. Wood, of Baltimore, had illustrated this by enclosing a tumbler of water within a chamber uniformly coated with phosphorescent paint; in these circumstances a glass of water, a glass prism, and other transparent objects completely disappeared.

He mentioned this to show how intimate a bearing the diffusion of light had on the experiences of the eye. The proper distribution of light might be quite

as important as the amount of light provided.

Mr. Gaster's paper having been read, a vote of thanks to the author was moved by Sir JOHN COCKBURN, who remarked that it was hardly possible to over-estimate the value of such a body as the Illuminating Engineering Society, and the great benefit which its impartial platform provided. Sir John added that an intimate relation might be found to exist between the amount of illumination desired and the brain. When the brain was dull the effect of turning on a number of lights, had, in his experience, a decidedly stimulating action. He fully agreed as to the desirability of keeping the source of light away from the eye, and throwing its rays on the object to be illuminated. The ideal system of illumination is that in which the actual source is invisible to the eye; in this respect we might well take a hint from the natural illumination derived from the sky in the daytime.

Mr. F. W. GOODENOUGH, in seconding the vote of thanks, expressed his appreciation of the zeal and energy with which Mr. Gaster had conducted the Society's affairs—of which he had had experience in his capacity as Chairman of the Council of the Society. He was also glad to have the opportunity of testifying to the harmony with which representatives of gas and electricity had worked together on the Council, and to the very able guidance of its President, Professor Silvanus Thompson. Mr. Goodenough added that at present the membership in the Society did not convey any professional qualification; but he hoped that in time to come when a qualifying examination would entitle members to use the term "member of the Illuminating Engineering Society," as an indication of their acquaintance with the subject of illumination. Sir John Cockburn and Mr. Gaster had both referred to the steady rise in the standard of illumination required in modern streets and buildings. In studying and prescribing the amount of light needed, proper methods of measurement were needed, and he hoped that before long we should be able to measure illumination in the same precise manner that we measure temperatures to-day.

Mr. R. G. SHADBOLT suggested that it would be very desirable for the Society to form local sections in the provinces so that members of the gas industry who did not reside in London could take more part in its proceedings.

THE CHAIRMAN remarked that there were many questions of equal interest to those concerned respectively with gas and electric lighting, and on which their standpoints were not antagonistic, and the Society had done good work in bringing these forward. He fully agreed as to the vital importance of methods of measuring light. Experience has shown that the measurement of electricity, once a difficult process, had become a very simple and easy matter to-day; but this was due to the labours of many scientific men who had prepared the way for modern conditions. If in the same way we could measure light and illumination with precision a great step would have been taken towards ascertaining what was desirable in practical matters.

The vote of thanks having been carried, Mr. L. GASTER briefly replied. He thanked Mr. Shadbolt for his valuable suggestion, which he said would receive the consideration of the Council. He quite agreed that something should be done to interest the provinces; only it must be remembered that a Society had to learn to walk before it could run.

Subsequently the papers by Dr. Meredith Young and Mr. Franklin Thorp (see pp. 565-570) were presented.

Mr. LEON GASTER proposed a vote of thanks to Mr. F. Thorp. In the course of his remarks he referred to some statistics prepared by the National Electric Light Association in the United States, showing that the "spoilage" of goods in that country amounted to millions of dollars per annum—even a small percentage saving on which (such as would surely be accomplished as a result of improved lighting) would amount to a considerable sum.

Mr. HAROLD E. BLOOR seconded the vote. He had been much struck by the change in the attitude of manufacturers towards illumination. Only comparatively recently it had been assumed that in a works where there was not much overtime, artificial lighting was of small

consequence. But manufacturers were now coming to regard the subject in a very different manner.

THE CHAIRMAN, in putting the vote to the meeting, related some experiences with incandescent mantles, and described some experiments showing how many burners were highly sensitive to sounds.

Mr. FRANKLIN THORP briefly acknowledged the vote of thanks.

Mr. F. W. GOODENOUGH, proposing a vote of thanks to the Chairman, referred to his remarks on burners, emphasising the importance to the public of buying only reliable types. The tendency toward supplying goods that were low-priced but not really cheap, was one against which both the gas and electrical industries had to contend.

Mr. J. ABADY, seconding, recalled a case of an inn at Stockport, where the mantle could be extinguished by throwing a shilling on the counter; curiously enough no other coin would produce this effect!

The vote of thanks having been put to the meeting and carried with acclamation, the proceedings then terminated.

(*The Conference of Manufacturers on October 29th took place too late for the proceedings to be included in this issue; we propose to refer to them in our next number.*—ED.]

Popular Lectures.

A word or two may be said regarding the series of popular lectures which took place each evening throughout the month in the Conference Hall of the Exhibition. Most of these were illustrated by demonstrations and lantern slides and attracted excellent audiences.

Professor Vivian Lewes, in his series of lectures on "The Evolution of Gas Lighting and Heating," dealt with the historical side of the subject in his inimitable manner. Other lectures by Mr. H. O'Connor on "The Contents of a Lump of Coal" and "From the Coalfield to the Burner" also served to give the visitors an insight into the ramifications of the processes involved in the preparation of gas. Mr. A. J. Martin, on "Harnessing the Forces of Nature for the Service of Man," gave a vivid idea of the loss of energy and material in our present methods, and discussed in some detail the heating of buildings by gas; an interesting suggestion was that the British Commercial Gas Association should build or equip a house or block of flats, so as to show completely how gas should be used for cooking, heating and lighting.

Other lectures by Mr. Miller Christy and Mr. Edward Lovett contained an interesting account of primitive methods of making fire, and the earliest methods of producing light; in the course of these lectures reference was made to the series of exhibits bearing on these subjects on show in the Exhibition.

Among lectures dealing with illumination we may note those of Mr. W. H. Y. Webber on the "Use of Gas in Factories for Lighting and Heating," and Mr. Leon

Mrs. Cloudesley Brereton.

Chairman of the Editorial Committee.

Gaster on "The Use and Abuse of Light." In the course of his lecture Mr. Gaster showed a great variety of slides illustrating good and bad methods of lighting. A special point was that the public judgment of an illuminant is much affected by the way it is used, and that it is therefore to the interests of gas companies to educate the public to use burners and mantles under the best conditions; and to avoid examples of the *misuse* of light.

A view of the Entrance to the National Gas Exhibition (taken at night time by artificial light.) The outside of the building was illuminated by a series of Keith high-pressure lights with silica cup, and above the entrance was an illuminated sign bearing the words "National Gas Exhibition."

Editorial Arrangements.

In conclusion a reference may be made to the excellent manner in which the editing committee did its work, and in particular to the hard-working chairman of the Editorial Committee, Mrs. Cloudesley Brereton, whose portrait is reproduced above. The fact of the papers presented at the Conferences being printed beforehand was a distinct advantage; and the catalogue of the exhibition was a model of what such things should be; and the wide attention given to the proceedings in the Press is convincing testimony to the organisation of the editing committee.

AN ACCOUNT OF THE LIGHTING ARRANGEMENTS AT THE EXHIBITION.

The Exhibition was primarily organised to show the great diversity in the uses and application for gas for heating, power, lighting, &c., but many of these applications have been fully described in other journals, and we propose merely to say a few words about the exhibits connected with illumination, and the general lighting of the Exhibition.

The most striking thing was the grouping of the exhibits. Instead of there being a number of stalls by different exhibitors, showing the same kind of goods over and over again, all the exhibits of one kind were grouped together; and there were a large number of joint displays showing the lighting of various kinds of rooms, to which quite a number of firms contributed.

This arrangement is naturally one to commend itself to the general public.

The first thing the visitor noticed was, of course, the arrangements at the main entrance. A special feature here is the use of over two dozen of the new 1,500-c.p. Keith high-pressure lamps fitted with silica cups round the mantles. The general appearance will be understood from the general view shown on p. 536. A cluster of the lamps is arranged on either side of the entrance. There are also others inside the towers, which strongly illuminate the white walls behind them.

In addition the front bears an illuminated sign, displaying the words "National Gas Exhibition" in black letters on a red ground so as to be clearly visible in the daytime; after dusk the letters were lighted up by a number of gas-jets, but this effect was rather overshadowed by the brilliant lamps near by. Along the hoarding on the left of the entrance a number of Pharos-Welsbach 4,000-c.p. high-pressure lamps were in use.

The Entrance Hall.

The chief feature in the entrance hall is the series of special Sugg fittings, which are shown in Fig. 1. These utilise a cluster of burners inside etched glass frames producing a restful and highly novel effect.

Passing through the turnstiles we come to the Industrial Hall, the general lighting of which is provided by a series of 600-c.p. high-pressure lamps down the gangways (Sugg lamps on the right, and Tilley lamps on the left). The exhibits in this hall were well designed to show the diversity of gas applications. Printing was being done under gas light; meter making and testing, mantle making and laundry work, were all shown in actual operation. A special exhibit was a training shop for gas fitter apprentices; here, too, work was busily in progress.

Illuminated Signs.

Passing onward we come to a display of illuminated gas signs, some lighted by transparency methods, others illuminated in an ingenious manner by concealed lights in the front; some of the signs were of the flash type, being lighted and extinguished at regular intervals. Such signs were also widely used throughout the exhibition over the entrances to the various sections, enabling the visitor to know exactly his whereabouts.

We come next to an arcade of shops brilliantly lighted externally and in-

FIG. 1.—A view of the Entrance to the Exhibition (looking towards the turnstiles); showing large pendant Sugg fittings, carrying 500-c.p. lights within diffusing glass shades.

(*Natural Photograph taken by Artificial Light.*)

ternally, and pass the stall of the British Commercial Gas Association, where a number of photographs and illustrations of the Association's work were on view.

A specially interesting exhibit near here was the collection of ancient lamps and fire-making appliances. The history of fire-making was illustrated by a series of models and photographs lent by Mr. Edward Bidwell. Mr. Edward Lovett showed a variety of primitive lamps coming from many different parts of the world and illustrating the great gulf between these old methods and our modern illuminants.

This arcade opened out into a space arranged to represent a miniature garden. In the centre of this was an exhibit illustrating the application of sulphate of ammonia and other by-products to the fertilisation of crops. In the background was a model country house in which the lighting of a complete series of rooms, from the bedroom to the greenhouse, was displayed.

Model Lighting Installations.

The passages leading on from this section were lighted by semi-indirect fittings and were also devoted to model installations in various types of rooms. For example, a series of rooms in a town house or flat, decorated in various styles, were shown, and billiard rooms, sitting rooms, and bathrooms, &c., were on view.

Photo. by J. H. Avery & Co.

Fig. 2.—A Model Studio. General lights by central shaded unit, movable standards carrying mantle in focusing reflector for local illumination.

It is interesting to note that semi-indirect lighting was very widely used at the exhibition, and this comparatively new method for gas lighting seems to be coming into general favour.

Passing beyond the bandstand we come to a model tenement in which another series of rooms furnished and

lighted in a more modest style were shown. An interesting item in this part of the Exhibition is the studio, the general illumination of which is provided by indirect units, while movable standard lamps having mantles concealed in opaque metal reflectors, can be used to concentrate the light on the model it is proposed to sketch. (See Fig. 2.) There is also a newspaper room fitted with bracket-lights for reading papers, but the method of illumination in this case was hardly so happy as in other installations, the lights being imperfectly screened and clearly visible to readers.

was divided into three sections, devoted respectively to a gas-works laboratory, a public testing station, and a section given up to general photometry, in which lamps up to several thousand c.p. could be tested. The chief object of interest in this room was the travelling photometric bench and rotating mirror arrangement for obtaining polar curves of light distribution, which was shown in operation. The adjustable mirror enables the light emitted at various angles to be determined in succession, the photometer used being of the flicker type. This exhibit did not, however,

Fig. 3 —A Night Nursery. Central indirect fittings and lights above each bed.

In Fig. 3 a view is shown of a night nursery illuminated by a central semi-indirect fitting, with lamps above each bed.

Photometric Exhibit.

In the engineering and miscellaneous hall there were a great many exhibits of stoves and heating appliances in the centre of the hall. One of the chief items was a photometer room fitted up by Alexander Wright & Co. This room

contain only photometric appliances, but also contained a collection of appliances for measuring and analysing gas, calorimeters and various instruments of the recording type. Mention should also be made of the meter-testing exhibit of the Liverpool United Gaslight Co.

There were also a number of interesting historical exhibits, including copies of original agreements, and cartoons and cuttings from newspapers of a century ago dealing with the introduction of gas.

In Fig. 4 is seen a view of the series of booths fitted up with wallpapers of different hues with the object of demonstrating to the public the amount of light reflected from the walls. The curtains could be drawn excluding all light from outside.

Lighting of a Model Schoolroom.

Passing a little further on we come to another exhibit in which illumination played an important part, namely, the model schoolroom which is shown in Fig. 5. This had approximately the dimensions of an average schoolroom and was fitted up with desks, blackboard, &c., but the fittings were selected with a view to showing various methods of treating the room. For example, the front part of the room was lighted by two units using an appropriate frosted globe and opal reflector, while the back portion was illuminated by semi-indirect units. As shown in the picture there is also a special unit for local illumination of the blackboard. Owing to the recently issued report of the Illuminating Engineering Society on School Lighting, and the frequent references made in the various conferences to this matter, the exhibit attracted much interest.

Next door was a display of church lighting appliances. (See Fig. 6.) Some of these showed the adaptation of shades and mantles to antique iron fittings. Special interest attaches to the semi-indirect type seen in the illustration. There were also examples of pulpit lighting, and the arrangement of local lights on reading desks.

Among other exhibits in this hall may be mentioned a series of business offices lighted mainly by Sugg ventilating lamps. Another demonstration took the form of a hotel kitchen, where modern methods of lighting and cooking with gas were illustrated. Cookery demonstrations and competitions were also organised daily, in a special room adjacent to the main restaurant.

The lighting of the café and tea room was carried out by chandeliers equipped with mantles in pink silk shades. A somewhat similar arrangement was used in the banqueting hall, but the illumination was decidedly more brilliant. In the rest room the idea of subdued lighting was also exemplified, lamps screened in

Fig. 4.—Booths illustrating reflecting power of wallpapers of various colours.

FIG. 5.—Model Schoolroom, showing general lighting by semi-indirect and shaded direct burners, with local light over blackboard.

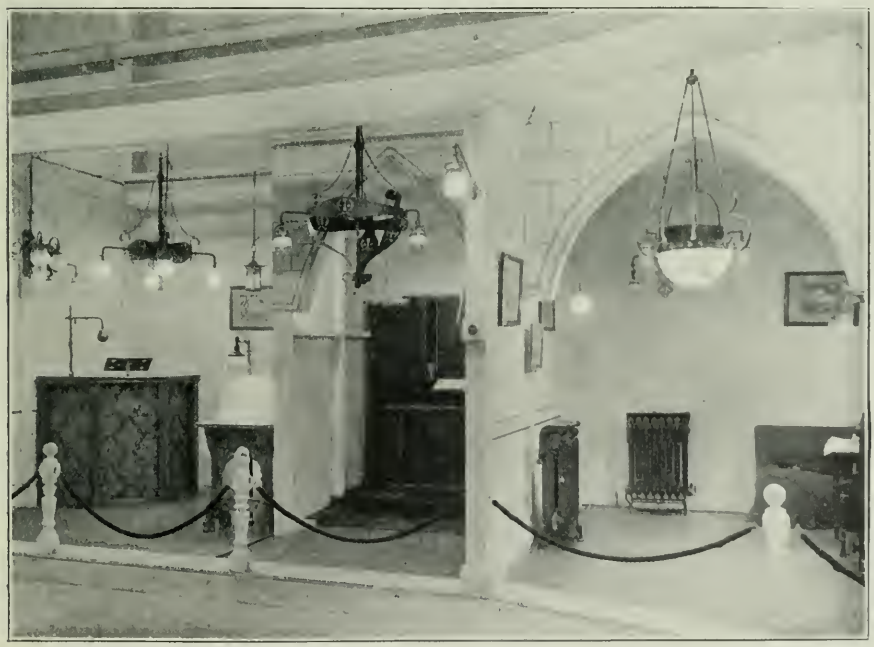


FIG. 6.—Illustrating adaptation of gas to church lighting, fittings, pulpit lighting, &c.

red silk shades being used. In the lecture theatre the illumination was provided by a series of five 28-light Nonpareil ventilating sun-burners, as well as various brackets on the walls of the room. A measurement in the course of the evening showed that the illumination on the seats was about 2·5 foot-candles.

Finally we have reproduced in Fig. 7 a view of the series of street lighting exhibits, adjacent to the banqueting hall. In the centre of the room were two high-pressure Keith centrally suspended lamps, with the new silica cups, and equipped with raising and lowering gear similar to that used in the City of London. Along the hall were a number of lamps by various firms ranging from the 100-c.p. low-pressure type up to units of several thousand c.p. of the high-pressure type, fitted with automatic distance lighters.

Systems of distance-control formed a special feature. Various modern pressure-water systems were shown in operation, and electrical methods applied to the smaller units.

It will be seen, therefore, that the Exhibition served to show the great variety of lighting methods now available. The photographs illustrating this article were taken specially for the ILLUMINATING ENGINEER with the exception of Figs. 2 and 7 which are reproduced from views taken by Messrs. J. H. Avery & Co., the official photographers to the Exhibition.

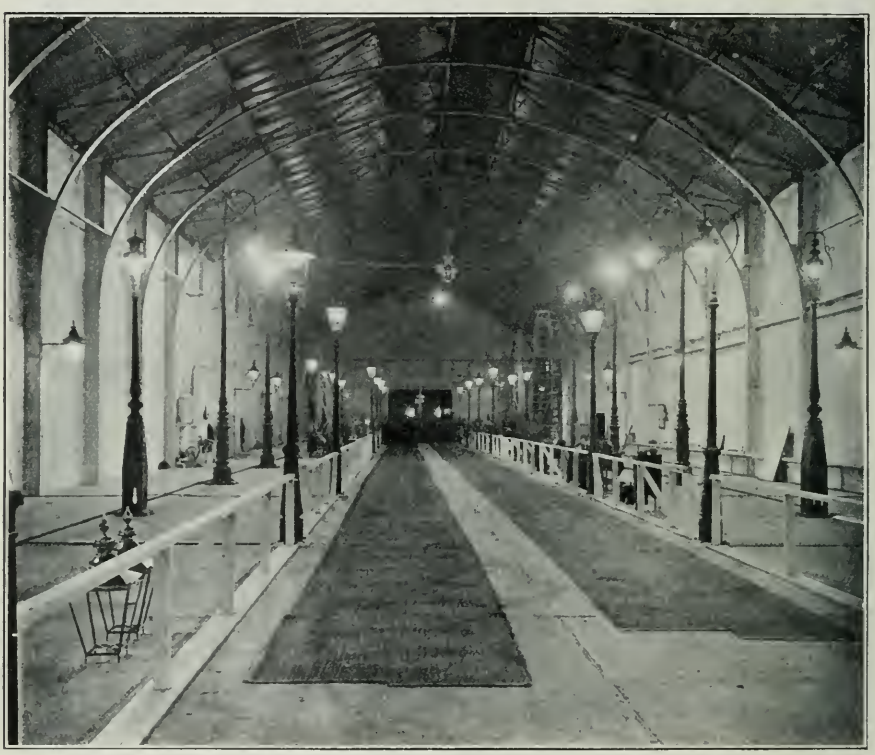


Photo. by J. H. Avery & Co.

FIG. 7.—A view of the Street-lighting Section, taken entirely by artificial light.

SOME CONSIDERATIONS ON THE BRIGHTNESSES OF LIGHTS.

By Professor Silvanus P. Thompson, D.Sc., F.R.S.

(Abstract of Paper Presented at the Conference of Educationalists at the National Gas Congress and Exhibition on October 11th, 1913.)

In spite of all the efforts of the men who have been studying and proclaiming the laws of illumination, there is a vast amount of ignorance still to be cleared away on the subject of good lighting. The observations now offered deal only with artificial lighting, not with daylight. They are not confined to any one illuminating agent, but deal with the subject broadly; since the laws of photometry are equally applicable to lighting by candles, oil, gas, electricity, or acetylene.

It is usual to express the intensity of any source of light in terms of "candle-power"—that is to say, by stating the number of standard candles that would have to be used to replace the source in question, if a light of equal intensity were to be produced at the place where the source is situated. This would in many cases be physically impossible: for instance, if an incandescent gas mantle is glowing with an intensity of 300 candle-power, it would be manifestly impossible to pack 300 standard candles together so that their flames should all be concentrated into the same space as that occupied by the mantle. When we describe such a source as of 300 candle-power all we mean is that its intensity is 300 times as great, or that it gives out 300 times as much light, as a single standard candle would do.

The bare statement of the candle-power of a source gives, however, no information upon another matter, viz., as to the *illumination* which the source produces upon a given surface such as a writing table or a wall. That illumination depends upon the distance of the source as well as upon its intensity. If the source be itself of small dimensions, as compared with its distance from the surface, the numerical value of the illumination received by the surface may be calculated by dividing the numerical intensity of the source by the square of the number of feet that the source is distant from the surface (here assumed to be orthogonally normal to the direction of the light). The unit of *illumination* is therefore that amount of illumination afforded by one standard candle at a distance of one foot; and is commonly called one *candle-foot* (or sometimes one *foot-candle*). As an example of the calculation of illumination, we may give the case of a surface illuminated by a source of 100 candle-power set 5 feet away. Dividing 100 by 5 times 5, we get as the answer that the illumination received is of the value of 4 candle-feet; or 4 times as high an illumination that would be produced by 1 candle 1 foot away. Special instruments, known as *Illumination photometers* (or *Lumeters*) are used to measure directly the illumination received at any surface.

Too great emphasis cannot be thrown upon the practical importance of being able to ascertain (whether directly by measurement with such instruments, or indirectly by calculation) the actual illuminations produced in various places. In a school, for example, the one thing that is most important to know is whether there is sufficient illumination afforded at the places where the scholars read and write, and at the place where the teacher writes on the blackboard. All the rest, the particular candle-powers of the sources, and whether they are electric or gaseous, is of as little importance as is the question whether the teacher travelled to school

at forty miles an hour by train, or rode at eight miles an hour in an omnibus. In public streets and squares likewise, the real question for town councillors, for members of lighting committees, and for borough surveyors, as well as for the public, is this: do the roads and pavements receive an adequate illumination. If they do, it matters not in the least, save as to the economic arrangement (which is a question of pure engineering), what the candle-power of the lamps may be, or what the nature of the illuminant. If the desired result—adequate illumination—is obtained, the consideration of the *means* whereby it has been obtained is a secondary question. Due illumination is an end to be attained: candle-power is a means of obtaining it. Whether that due illumination is better attained by a few lamps of great candle-power or by a larger number of lesser candle-power, depends on the particular circumstances of the case.

But there is another point in respect of which the mere statement of the candle-power of a source gives no information: viz., the question of its *intrinsic brightness*, or *luminosity*. Suppose two lamps to be of equal candle-power—say a 10-candle electric fairy lamp, and the other an old flat batswing gas burner giving a 10-candle light. Viewed from a distance of four or five yards one appears a brilliant point of light, the other an object of appreciable size much less brilliant in itself. One will seem to cut the eyes much more than the other, though both produce equal illumination at the same distance. They will not seem equally bright or brilliant. The reason is that the images these lamps produce (at the same distance) on the retina of the eye are not of the same size. The image of the smaller lamp is correspondingly smaller than the image of the larger flame; and as equal amounts of actual light are received in the two images, one will be more concentrated than the other, and the nerve structures of the retina will be differently stimulated. There will be a strong stimulation by one lamp over a small patch of the retina, and a weaker stimulation by the other source over a larger patch of the retina. The eye, in fact, is physiologically disabled from being able to equate together two equally powerful lights if the concentration of their respective intrinsic luminosities is different. At the best the human eye is a very bad photometer. Its automatic adjustment which closes the pupil in presence of a flood of light, and opens it in twilight—a most invaluable provision of nature—works against it as a measuring instrument. And Fechner's law of psycho-physiology, concerning the numerical relation between a stimulus and its resultant sensation, shows, once and for all, the impossibility of setting up the eye as a judge of photometric values. The one and only thing that the eye can do in this regard—and it is the principle of every photometer—is to draw a judgment as to the equality or non-equality of the illuminations on two adjacent patches of space in the field of vision.

This question of the intrinsic luminosity or brightness of lights has scarcely received the amount of attention it deserves. It is this which makes a naked or unobscured electric glow-lamp so unendurable to the gaze. It is this which leads people to put semi-opaque globes or shades round lamps to "*diffuse*" the light—that is to make it seem to emanate as it were from a larger object; since if thus diffused or spaced out, it no longer cuts the eyes, the retinal image being larger and less concentrated. But opal globes and ground glass shades—to say nothing of devices of paper or silk—waste an unconscionable percentage of the light. Modern dioptric globes are far less wasteful: they enlarge the visible outline of the source, but with a minimum waste by absorption. The intrinsic brightness of different kinds of luminous sources is expressed scientifically in terms of candle-power emitted per square inch of area. The flame of a standard candle presents 0·4 of a square inch of apparent surface; hence its intrinsic brilliancy is about 2·5 candles per square inch. The following are some values for the intrinsic brilliancies of some sources:—

Candle	2·5
Argand Gas Flame	8·6
Incandescent Gas Mantle	80—250
Carbon Filament	50—200
Tungsten Filament	700—900
Electric Arc Crater	1,030

The higher the intrinsic brilliancy, the more unendurable is the brightness of

any source. We know how blinding—how dangerous, in fact—it is to look directly at the sun. It appears to us as a round disc of the same apparent size as a threepenny-piece held at arm's length, glowing with a light estimated at 200,000 candles concentrated in that small circle. But if we could diffuse it out to forty times its apparent diameter, and thus spread its light over an apparent area sixteen hundred times as great, its apparent brightness would come down to only 125 candles per square inch. The bedazzlement of the eye by lights which are highly concentrated is a very undesirable result. It reduces the power of the eye to see clearly other objects that may be within the same field of view. There are a number of kindred phenomena which result in interference with perfect or comfortable vision. A light that is too bright, whether concentrated or not, dazzles the eyes and causes discomfort in vision. Very smooth paper acts partly as a mirror, and reflects too much light at particular angles, interfering with the ability to see what is printed or written on it. Engineers give the generic name of *glare* to all these effects, and strive to avoid all causes of glare in their attempts to attain good lighting.

Another phenomenon which affects ease of vision is that of *irradiation*. In consequence of the imperfections of the lenses of the human eye, a bright point is never perfectly focused on the retina as a point, but its image is a more or less blurred patch. A bright line is never focused as a line of the proper width, but is always seen broader than it ought to be. A bright defined area, such as a white circle or a white square on a black background appears to be of larger size than it is, owing to this defect of focusing, which makes the bright surface appear to encroach on its background. The converse happens with black dots, black lines, and black areas on white grounds. Black lines on white grounds always appear thinner than they really are: the light encroaches on the dark. This is the justification for using white chalk on blackboards instead of employing charcoal on whitened boards. The phenomenon of irradiation also affects printed type. Types designed with thin vertical strokes are less legible than those with thicker, since they are printed in black on white. The reverse would be the case if things were printed in white on black. The makers of public advertising plaques and of illuminated signs know this, as shown by their preference for white or pale yellow lettering on black or dark blue grounds, and for designs of letters in which thin vertical lines are not used. The relative invisibility of thin black lines on white grounds is enhanced if the white background is very bright. This is one reason why printed matter on a shiny paper is so bad to read.

The good lighting of a room depends not only on the disposition of the lights so as to produce an adequate illumination, and on the proper shielding of the lamps so as to avoid needless glare, but on the nature of the wall-surface on which the light falls. Even when the illumination that is received by the walls is ample, the room may be badly lit, if the walls absorb too much of that illumination instead of giving it back by diffuse reflection. Few people are aware, what illuminating engineers know, how much light is thus wasted and thrown away. White cartridge paper absorbs and wastes about 20 per cent. of the light; a white-washed wall absorbs from 30 to 40 per cent.; an ordinary yellow or buff wall-paper usually wastes 50 to 60 per cent.; the deep scarlet and crimson wall-papers now fashionable for dining rooms waste from 70 to 75 per cent.; brown paper wastes about 85 to 88 per cent. Clearly, for economy in artificial lighting, and for comfort in the daylight lighting of large rooms, the ceilings should be invariably white, and the walls, if not white, should be of the palest tints.

During the last two years the Illuminating Engineering Society has had valuable reports prepared for it by three special Committees; one on Street Lighting, one on Library Lighting, a third on School Lighting. I will speak only of the last. They recommend that for ordinary work in reading and writing the minimum illumination at any desk should not be less than 2 candle-feet: some members of the committee favouring a minimum of 2½ candle-feet. For special work, such as drawing, stitching, and the like, the minimum recommended is 4 foot-candles. For

blackboard illumination 2 candle-feet is admitted to be sufficient only for small class-rooms where the students are within 20 feet. The lamps for lighting the blackboard should be screened from the eyes to prevent glare. The Committee lays some stress on the use in general of shades or globes which diffuse the apparent brightness of the source over a considerable area so as to reduce what I have called the bedazzlement caused by lights that are too concentrated. It goes without saying that the Committee favours the use of indirect lighting in which the rays of the lamps are intercepted and thrown upon ceiling or walls only, so that a soft diffused light alone reaches the eye. The disadvantage of this method is that it is almost shadowless. For reading and writing this is good ; but the visibility of solid objects and raised surfaces greatly depends on the presence of shadows, and for such a direct illumination is preferable. All school managers and school architects would do well to study the recommendations of this Committee.

THE SCHOOL OF THE FUTURE: ITS LIGHTING, HEATING, AND VENTILATION.

By Septimus Warwick, F.R.I.B.A., and Austen Hall, F.R.I.B.A.

(Paper read at the Conference of Educationists at the National Gas Congress and Exhibition on Saturday, October 11th, 1913.)

In this paper the authors have much to say on the subject of heating and ventilation, but the section of the paper of chief interest to us is naturally that dealing with illumination.

The authors deal with artificial lighting mainly by reproducing *in extenso* the Interim Report of the Joint Committee appointed by the Illuminating Engineering Society to discuss this subject. Some of their remarks and suggestions should be taken to heart by architects. For example, it is pointed out that the lighting of any building is intimately associated with its construction :—

Here, as elsewhere, prevention is better than cure. It is a very expensive matter to remedy blunders concerning illumination, heating, and ventilation after a school has been built and fitted up. This is especially true in regard to daylight illumination, it may be noted ; for one cannot easily take a building up and turn it round so as to utilise the sunlight to better advantage. We are all, in these days, paying increasing attention to preventive medicine. Let us also give close attention to preventive hygiene and preventive common sense.

In these matters there is obvious necessity for close co-operation between the architects who have to plan the buildings, the medical officers who are responsible for the health of those who will have to occupy them, and the committees and teachers who are responsible for the success of the work carried on therein, using the word success in its broadest and truest meaning.

The old idea that the architect's business was to plan buildings without reference to those who had afterwards to live in them should be, if it is not, quite exploded.

There is another body with which the architect is now able to consult in these and similar matters, and that is the Illuminating Engineering Society, which promises to be a most useful consultative body, and is doing valuable work in calling attention to the greater need for the application of scientific principles to the illumination of our homes, schools, factories, and other premises.

In commenting on the recommendations of the Committee the authors regard semi-indirect methods of lighting to those of an entirely indirect character. An important point to be noted is the need for *proper maintenance* in schools, otherwise the lights are apt to get into a bad condition. The facilities in this direction provided by modern gas companies for maintenance should therefore not be overlooked.

THE PHYSIOLOGICAL AND MENTAL DISADVANTAGES OF UNSCIENTIFIC ILLUMINATION.

Some Conditions to be observed in the Lighting of Schools,

By Leon Gaster

(Hon. Sec. of the Illuminating Engineering Society).

(Abstract of paper presented at the Conference of Educationalists at the National Gas Congress and Exhibition on October 11th, 1913.)

From the earliest days light has been recognised to exercise an important influence on social conditions, fostering culture and mental development by enabling labour and recreation to be prolonged in the evening hours when daylight is gone. We find a direct connection between lighting conditions and the health and spirits of people. In a good light they work more willingly, but are readily depressed by gloomy sombre conditions.

Good lighting is of vital importance to the adult in his daily occupation, but still more so to the child at school, or even in the nursery. It is therefore the duty of the parents to see that any reading or fine work undertaken by the children is not done in gloomy ill-lighted corners of the room. But while reading at home is optional, study at school is *compulsory*. How much greater, therefore, is the responsibility of school authorities to see that the school-rooms are well lighted! Medical authorities tell us that a progressive deterioration in eyesight occurs during school life. We can readily understand why this should be the case. For a child working by insufficient light instinctively tries to bring the book nearer to his eye, or bends so as to bring his eyes nearer the work. This constant close vision is believed to be one of the main causes of short sight. Moreover, the habit of assuming a stooping attitude is bad for the figure of the child. Children are sometimes blamed for such habits. But are we sure that the blame should not rest on his elders, for allowing bad conditions of illumination to exist, and so paving the way for the stooping habit?

Dr. James Kerr, Medical Officer to the London County Council, has also pointed out that light coming from the wrong direction and casting inconvenient shadows of the body, causes children to assume a cramped, unnatural attitude, when reading and writing, and may even lead to spinal curvature. Dr. Kerr also points out that a child, to whom the characters are unfamiliar, requires good light even more than a grown-up person, to whom reading has become second nature. For the same reason school books should be done in large type on dead white or cream paper. A Committee of the British Association recently dealt with this point, prescribing in detail the size of type and number of words per line permissible for children of different ages. Small type and involved diagrams are doubtless the cause of much eye trouble among young children and add to the difficulties of their work. A case might also be made out for more vigorous supervision of the sensational novelettes and cheap literature issued broadcast among the children of to-day. Many such publications are printed execrably on very poor paper. Children are apt to read them more or less secretively in corners where they will not be interfered with, but where the illumination is usually

poor. This combination of poor light and inferior printing cannot be good for the child.

Habitual work in a poor light, besides being prejudicial to the eyes, may therefore be detrimental to the general nervous system, for it increases the strain of work at a critical period in the child's development. Then again a child who is short-sighted loses much of what goes on round him, and is often put down as stupid or inattentive. Thus poor lighting, by causing defective vision and impairing one of the channels by which information is received, also prejudices the brain development and may interfere with a child's education—a serious handicap in after life.

There is one other strong argument that may be brought forward on behalf of good lighting in the schools. The illumination should be good, for the same reason that the schoolroom should be cheerful and clean—because it serves as an example to the children. If they find in the schoolroom makeshift and antiquated methods of lighting they go out into life with a low standard in this respect, and so the evil is perpetuated. If, on the other hand, they find that every room they enter is carefully lighted, that the illumination is always sufficient, that the lamps are properly shaded and kept clean, &c., they, in turn, will try to secure the same conditions in their own homes. There is an intimate connection between cleanliness and good illumination. A badly lighted gloomy room naturally is not kept as clean as it should be, since the dust cannot be seen. Living in poorly lighted rooms also encourages neglect of personal appearance. One of the most important influences in the elementary schools to-day is the training of children in healthy habits. We may be sure that a well-lighted classroom makes the teacher's task easier in this respect; and that in a poorly illuminated room the supervision of cleanliness will be less thorough.

The question may next be asked "What is meant by good lighting" in a schoolroom? Authorities in the chief countries of Europe and in the United States have recently been busy on this matter. It was referred to at the International Medical Congress in London this August, and was also the subject of special discussion at the Fourth International Congress on School Hygiene just concluded in Buffalo. In addition a special committee composed of members of the Illuminating Engineering Society, the Association of Medical Officers in Schools, the Association of Teachers in Technical Institutions and other kindred bodies has recently issued a preliminary report on the subject.

A few of the most important points may therefore be mentioned. In the first place, the illumination on the desks where the children read should be *sufficient* The Committee recommend that the illumination on no desk should be less than 2 foot-candles * (some members of the committee preferred $2\frac{1}{2}$ foot-candles). A considerable number of tests have been made in schools in London, and it has been ascertained that an illumination of this strength is quite practicable. The figure has also a theoretical basis, for the researches of many physiologists seem to show that the eye becomes, as it were, "saturated" at this point, so that for reading purposes, any great increase in illumination past this point produces relatively little increase in sensitiveness. This, of course, refers to large type on good white paper. On the other hand, when sewing with dark materials is undertaken a very much greater illumination would be needed, for the simple reason that such cloth reflects back to the eye but a small proportion of the light it receives; and though the illumination may be high, the actual *brightness* of the material will be small. Sewing always requires a good light, and it has been recommended that all fine work of this kind should *only be done during the daytime.*

Another point that received attention from the committee was the avoidance of "glare." The dazzling effect of modern electric filaments and mantles is apt to be very trying and fatiguing to the eyes when such lights fall in the direct line of view. It is therefore essential to ensure that the lamps are properly shaded, and

* By a "foot-candle" is meant the light received from a lamp of one candle-power, one foot away. Two candles set up one foot away from a white surface would give approximately the illumination suggested above.

that they are kept, as far as possible, out of the view of scholars looking towards the blackboard. In a small classroom the general lighting may suffice to light the blackboard, but in many cases, especially where diagrams in coloured chalk are used, special local lighting of the blackboard will be needed.

Among other points considered by the committee are the avoidance of inconvenient head-shadows and troublesome reflections from shiny paper, &c. For school-books a dead white paper is preferable to a glazed variety. Both these defects can be mitigated to some extent by arranging for the ceiling in the room to be white and the walls light in tint, so as to reflect the light to and fro, and produce good diffusion of light. The possibilities of the indirect and semi-indirect methods of lighting for classrooms also merit consideration, but opinion is divided as to their utility.

The Committee of the Illuminating Engineering Society is now considering the natural lighting of schools. There are many questions, such as the best size and shape of classrooms in relation to the window-space, the comparative merits of "unilateral lighting" (lighting from windows on one side of the room only) and "bi-lateral lighting" (windows on both sides), &c., still being debated. Seeing that so large a proportion of school work is done in the daytime the planning of schoolrooms is an important matter.

These are a few of the considerations that may be urged in favour of scientific school lighting. Quite recently an important scheme of inspecting the physical conditions of school children has been introduced, and it seems natural to suggest that the scheme of inspection should include a study of the lighting conditions. The provision of glasses for weak-sighted scholars is certainly a step in the right direction, but it is surely still more important to remove the causes of defective vision—among which may be reckoned poor illumination. The gravity of the matter may be realised when it is stated that there are in the schools of London alone over 1,000,000 children. The preservation of the eyesight of the coming generation is a matter of national importance, and the good work that is being done in this direction by this conference and by the co-operation of the Illuminating Engineering Society deserves emphatic recognition.

LECTURES ON ILLUMINATION AND PHOTOMETRY.

We notice that a special course of fourteen lectures, devoted to illumination and photometry, commenced at the Salford Institute on the first of last month.

The lectures are delivered by Mr. D. H. Ogley and cover a variety of topics, including photometry; electric illuminants, light and the eye; direct, indirect and other methods of lighting; the design of shades, auto-car headlights, &c.

We are glad to see this enterprising treatment of illuminating engineering, and hope that similar courses will soon be instituted at other technical institutions in various parts of the country.

ILLUMINATION IN SCHOOLS.

In the report of the Medical Officer of the Rhondda Urban District Council for 1912 the following reference to lighting occurs :—

Lighting.—Gas, or in a few instances, electric light, is used when natural light is insufficient. In many class-rooms of the older schools the direction from which light is admitted in relation to the scholars is at fault, and in a number of cases the defect does not seem capable of being satisfactorily remedied. In the more modern schools, however, the direction from which light is admitted is generally correct.

Reference is also made to the occasional dirtiness of the upper parts of windows. The appointment of a male cleaning staff has effected a decided improvement.

THE HYGIENE OF GAS FOR LIGHTING.

By Dr. S. Rideal.

(Abstract of Paper presented at the National Gas Conference and Exhibition on Tuesday, October 14th, 1913.)

The hygienic advantages of gas as an illuminant can be discussed without reference to other forms of illumination. In all problems of this character, the economic aspect of the question cannot be ignored, labour-saving devices, and the absence of worry, the relative cost of the raw material, and its ease of appliance, and what may be called maintenance, waste and renewals, have all important influence upon the problem of health.

Since gas was introduced for lighting purposes the burner has been developed from the old batswing pattern, giving about a candle per cubic foot, to the modern incandescent burner, which gives about twenty times as much light for the same amount of gas. In the old days, the best form of lighting was obtained in an Argand burner which gave a light of 14 or 16 candles per 5 cubic feet per hour, and this is still a standard in this country for the sale of gas. It is to be hoped that next session will see the abolition of this standard, and that England will be in line with other continental countries, where it is now almost universal for a calorific standard to be used for the sale and control of gas.

It must not be forgotten that the price of gas to the consumer depends largely upon the costs of distribution, and all encouragement should be given towards a uniform load throughout the year and a level maximum duty in the distributing mains; this can only be brought about by increased development for heating and power purposes. When we come to analyse the distribution of the heat units of a ton of coal when gasified, we find that about one-fifth is consumed in the works for the conversion, one-half remains in the ungasified coke, but 25 per cent. of the original heat is available for utilization in the distributed gas. The modern gas fire with its new "radiants" is so designed as to emit roughly half the total heat energy of the gas into the room, and this shows an enormous improvement on the older forms of room heating. It may be mentioned that the city of Glasgow in 1909 made exact comparative trials on a practical scale as to which was better for heating houses, coal or gas, as regards efficiency, healthiness and economy, and decided the question in favour of gas on all three points.

During 1907 I made a series of comparative trials on a practical scale of the relative hygienic values of gas and electricity as used for ordinary domestic lighting (J. Roy. San. Inst. xxix., 2, 1908). A large room measuring 29 ft. 9 in. by 16 ft. 4½ in. and 10 ft. 4 in. high, having a capacity, allowing for chimney breasts, &c., of 5,013 cubic feet, was employed for this purpose; during part of the research the room was divided into two equal and symmetrical rooms. Gas and electric lamps were fitted, the number, power, and position of these lighting units being as nearly as possible identical. Experimental runs were made each evening with either gas or electric lighting and physiological observations were made on 15 persons, a general medical examination of each subject having been made before being included for the tests. During the runs the temperatures, humidity, ventilation and bacteriological condition of the air in the rooms were systematically determined. The ventilation of the room was determined on each day immediately before and after each experimental run. The average with the divided closed rooms during a run with gas was 2,002 (air supply in cubic feet per hour), and

with electricity 1,950, the slightly increased ventilation in the former being caused by the gas. It is not possible here to go into any detail of these extensive experiments, but a number of interesting facts bearing directly on our subject were disclosed during this work.

In conjunction with Dr. Hehner I had previously shown that one of the products of gas lighting, the sulphur compounds, are practically entirely absorbed by the ceilings and condensation on the walls, &c., in an ordinary dwelling house. In this instance inquiry showed that the amount of whiting which had been used in whitewashing the room before it was taken over for the research, was about 50 lbs. (350,000 grains). 100 grains of whiting combine with 32 grains of sulphur, so that the new whitewash was capable of fixing 112,000 grains of sulphur. Using 4 cubic feet of gas per lighting hour, containing a maximum of 60 grains per 100 cubic feet, five hours' lighting per day would give a daily evolution of 12 grains of sulphur, so that the room would remain basic for 9,333 days, or its sulphur-absorbing power would not be exhausted for 25 years.

As regards CO_2, water and heat, the changes in the air of the room by the human contributions far exceed those caused by either illuminant. Attempts to estimate expired CO_2 of the inmates of the rooms with a spirometer failed owing to abnormal breathing of the subject when tested, but the amount was found by calculating from the total CO_2 present in the air when the room had reached its "steady state," allowing for ventilation and subtracting other sources of the gas. An average of 0·8 cubic foot expired CO_2 per man per hour was found, this figure being in close agreement to the estimates of several well-known authorities. In an ordinary dining-room of the size of the divided rooms used for part of these experiments there would often be as many as six men at a time. The yields of heat, moisture and CO_2 from two burners and six men respectively are set out in the following table :—

Hourly Production of :	Two 25 c.p. Electric Lamps.	Two 25 c.p. Gas Lamps.	Six Men.
Heat in B.T.U.	658	1,382	2,040
Moisture in grains	——	1,012	4,200
CO_2 in cubic feet	——	1·54	4·8

The next table shows the changes which these quantities would bring about in one hour in the temperature and composition of the air of the room, the capacity being taken at 2,500 cubic feet, the initial temperature at 40° F., the humidity 69 per cent. (corresponding to ·21 gr. of water per cubic foot), and the carbonic acid at the ordinary figure for town air, viz., 4 parts in 10,000.

——	Two 25 c.p. Electric Lamps.	Two 25 c.p. Gas Lamps.	Six Men.
Rise in temperature	13·9° F.	29·1° F.	43° F
Final temperature	53·9°	69·1°	85°
Added moisture, grn. per cub. ft. ..	·0	0·4	1·68
Final humidity at raised temperature	43 per cent.	31 per cent.	31 per cent
Added CO_2 parts in 10,000 ..	——	6·2	19·2
Final CO_2 ditto ..	——	10·2	23·2

It will be seen that, as already mentioned, the alterations brought about in the air of the room by the human contributions far exceed those from either illuminant. The figures assume that the air of the room is stationary: in actual experience the variation is much less, on account of ventilation. With an air supply equal to three times the contents of the room, which may be taken as a measurable maximum, the changes would be proportionably smaller, the increase in the CO_2 becoming 2·1 and 6·4 parts from gas-burners and men respectively.

CO_2 is commonly taken as a measure of the purity of air much in the same way as coli organisms are counted as an indicator of the purity of water. Expired breath from the lungs contains on an average 4·3 per cent. of CO_2 (430 parts per 10,000), and an amount of CO_2 above this in air produces sickness or even death. In these experiments it was found that CO_2 in quantities up to 50 parts per 10,000, even when of respiratory origin, is not responsible for any physiological effects. The CO_2 figure was as high as 53·2 during one experimental run, and frequently was over 40 without becoming apparent to the senses or in any way affecting the health of the occupants. Many of these high figures were reached in electric-lighted rooms, the CO_2 being then, of course, almost entirely of human origin. It would be a very poorly ventilated room in which even 20 parts in 10,000 would be found.

The humidity results throughout the experiments showed remarkably close agreements with electricity and gas, proving that the illuminant has but little effect in this direction, the relative humidity of the air in general was 70 to 75 per cent., and was therefore such as the best authorities have laid down as most agreeable. In explanation of the equable humidity maintained in the rooms apart from the ventilation, it is obvious that the walls, &c., serve as a compensating reservoir either taking up or giving off moisture according to the wetness or dryness of the air.

Detailed investigations were also carried out on the change of weight, respiration and heart action of people in the two rooms.

In confirmation of the popular idea that electric light is more trying for the eyes than gas-light, the records of the ophthalmic experiments were distinctly in favour of gas lighting.

The amount of carbon monoxide, CO, in air forms a very delicate test for the presence of unburnt coal-gas due to any leak; this can be determined by Nicloux's process.

I have investigated the physiological effects of a large coal-gas leakage. Three subjects were enclosed in a room of 2,500 cubic feet capacity 4 hours 20 minutes, in which 8·8 cubic feet of gas per hour was allowed to escape; this was calculated from the carbon monoxide and ventilation determinations to correspond to a permanent gas leakage of 0·9 cubic foot per hour.

Detailed physiological tests before and after the experiment were made. No prejudicial symptoms were detected, and from this experiment the inference is that in any quantity of gas likely to escape from an ordinary leakage there is no fear of any immediate danger to health.

At the present time, when so much attention is being directed to the Healthy Home, Town Planning and Suburban Development, the subjects of heating, lighting, and air pollution are of immense importance. Even without any legal enactment on the point, it is the duty of every householder to discontinue, so far as possible, the domestic use of coal.

The proper employment of gas utilises money and labour most profitably, besides contributing to the cleanliness and healthiness of homes, while the raw product coal, which is a national asset, will be increased in value. Dr. Lessing the other day at the British Association Meeting calculated that if all household coal were carbonised before being used for domestic purposes, not only would the "smoke nuisance" be abolished, but that, at 20 gallons per ton, 700 million gallons of liquid fuel per annum would be obtained, or some 15 times the quantity of liquid fuel required for the Navy.

THE AIMS AND OBJECTS OF THE ILLUMINATING ENGINEERING SOCIETY.

By Leon Gaster

(Hon. Sec. of the Illuminating Engineering Society.)

(Abstract of paper presented at the National Gas Conference and Exhibition on Friday, October 17th, 1913.)

Before proceeding to explain the aims and objects of the Illuminating Engineering Society, a few words may be said as to its origin. It is now seven years ago since the author first sought to obtain support for the project, but it was not until the autumn of 1907 that the idea was brought prominently forward. In the meantime the author had visited the Continent and the United States. Encouraged by the favourable views of the leading experts of those countries, he revived the idea in a paper before the Association of Engineers in Charge in the autumn of 1907, and endeavoured to point out the valuable work such a society might do. The great advances in methods of lighting commencing at that time, and the introduction of new illuminants and improved apparatus for making use of them, all served to emphasise the need for an impartial platform for the discussion of the subject of illumination. Yet the support was not very encouraging. People were unable to see how the representatives of gas and electric lighting could be got together on the same platform, and there were few who realised what an immense ground was covered by the term "illuminating engineering." The starting of the Illuminating Engineer in the following year helped to explain the nature of the movement more fully, but it was not until 1909 that the Society was actually formed. By that time many of those who originally had doubts as to the utility of the movement had changed their mind. At the present day, it is pleasant to record that many of those who originally opposed the idea have become its strongest supporters.

As an exposition of the aims and objects of the Society one cannot do better than quote from Prof. Thompson's inspiring inaugural address, delivered at the first meeting of the Society in 1909 :—

"This Society," he said, "has been founded to bring together all those who are interested in the problems, practical and theoretical, of the art of directing and adapting light, that prime necessity of civilised, as well as of uncivilised existence, to the use and convenience of man. . . . Few members of the community at large are producers of light, and those who produce light have many diverse and often rival processes. But all members of the community are *users* of light. And between the producer and the user there stands a considerable number of persons, mostly professional men, not middlemen, in the industrial sense, but persons who are concerned with the intermediate questions of distribution and utilisation, for whom no professional name has hitherto existed, and who have had no organisation to bring them together, to consolidate their experience, or to voice their opinions. Their diverse and individual interests centre around a common topic—and, in default of a more appropriate name, that topic is called 'illuminating engineering.'"

Professor Thompson proceeded to explain that there were many problems (such as the measurement of light and illumination, the avoidance of glare, the design of shades and reflectors, the appropriate position of lights in interiors, &c.), which are of common interest to representatives of all systems of lighting. For these the Society has provided a common platform, where they can meet together on

friendly terms and discuss points in which they are mutually interested. But it has also opened its doors to the architect, the medical officer, the physiologist, and to many others whose advice it desires and whose co-operation it needs. All of us feel that we are engaged on what Professor Thompson happily termed "a career of self-education." Membership in the Society does not at present convey any professional status, and for the present we deprecate members describing themselves as illuminating engineers, feeling that the ideal "illuminating engineer," conversant with all aspects of the subject, has yet to be evolved. We particularly desire the support of the architectural profession, at present insufficiently represented in our Society. We feel that while the architect might often learn much from the engineer, the latter could also learn much from the architect; and that the influence of the Society, with the architect's assistance and support could do much to bring home to the general public the possibilities of developing not only more efficient but also more beautiful conditions of lighting.

At present, it must be owned, the architect in whose hands the lighting of interiors so largely rests is often indifferent to these possibilities. We want him to take up illumination as an integral part of his work, and to help us to raise it to a higher artistic plane.

In the same way we feel that the influence of the medical profession should be exerted more strongly against methods of lighting detrimental to vision. All our impressions as to the beauty or utility of an interior are received through *the eye*, and in designing a lighting installation we should surely study the needs of this organ. At an early stage in the Society's proceedings the "glare" from artificial illuminants was discussed, and vast results have already followed from this discussion. The lighting engineer has been stimulated to design new and improved forms of shades and reflectors screening the light from the eyes and producing a more restful efficient condition of illumination; and the medical profession are coming to recognise that they have a duty to apply their knowledge of the eye, acquired in the physiological laboratory, to practical problems in illumination. At the recent international Medical Congress, held in London, much was said on this point; but much more may yet be learnt by the closer co-operation of the medical profession and the illuminating engineer.

Another respect in which the influence of the Illuminating Engineering Society has been far-reaching is the design of simple instruments for the measurement of illumination—once regarded merely as a laboratory process of theoretical interest, but now generally felt to be quite a practical and familiar process. We are now no longer content to say that the illumination must be "adequate." We want to know exactly what "adequate" means, and we are already replacing this vague term by precise recommendations as to the amount of light required for various purposes. In order to do this we must make the measurement of illumination as natural a process as the measurement of temperature, moisture, or the percentage of carbon dioxide in the air; and we are well on the way towards doing so.

Other meetings of the Society have been remarkable for their influence in bringing in contact those interested in the development of lighting appliances and those concerned mainly with the use of them. We have dealt with such subjects as the lighting of schools, shops, libraries, printing works, railways, &c., and in each case we have been successful not only in ourselves learning more about these subjects, but in bringing their importance home to many members of the general public outside the ranks of the Society. Professor Thompson, in 1909, foresaw that such discussions would reveal possibilities of further work such as might fitly be dealt with by the formation of joint committees. "One of the things," he said, "that I think our Society might well undertake would be the formation—in the manner of the British Association or of our sister societies—of technical committees charged with the duty of preparing reports in different branches of our subject."

Well, we have already arranged, in conjunction with other bodies, for committees on street-, school- and library-lighting, and no doubt we shall be able to do much further in this respect

in the future. At the Conference of Educationalists at this exhibition on Oct. 11th, reference was made to the report of the joint committee on school lighting and its recommendations seem to have received a very cordial reception from all interested in the subject. The recommendations of such joint committees naturally carry weight in the public mind in a way that the views of an individual, however gifted, will rarely do. By this means an authoritative and clear exposition of the principles of good lighting can be laid down for the benefit of the consumer. To the manufacturer, too, it is of great assistance to have a series of definite recommendations on which to base his proposals, and to have at his back the authority of an impartial expert committee.

A gratifying feature of our work has been the wide publicity given to all the discussions of the Society in the press. That shows that illumination is a subject in which literally everybody is interested. The generous and wide publicity given to our work in the press, which we should like to take this opportunity of cordially acknowledging, is doubtless also due to the fact that the Society has from the first granted every facility for the reproduction of its proceedings and done everything it could to assist journals and papers interested therein.

Besides the work of its committees the Society has also been responsible for the circulation of a little booklet entitled *Light and Illumination: Their Use and Misuse*, which summarises, in a popular manner and by the aid of appropriate illustrations, some of the fundamental rules of good lighting. This also has received very wide notice. Its contents were arranged in such a way as to be applicable to both gas and electric lighting and it may be remarked that both the British Commercial Gas Association and the Electrical Publicity Committee have arranged to circulate a considerable number of reprints. This surely is an emphatic testimony to the value of the movement to both systems of lighting. It is hoped that this booklet will be followed by others dealing specifically with various problems in illumination.

Let us now turn to another aspect of the work of the Society—its international connection. Naturally the same problems that interest us in this country are also occurring abroad. In illuminating engineering, we have early recognised the wisdom of international co-operation; seeing that this is a new and developing science, and that conditions in different countries have not yet become standardised, the prospects of common agreement at an early stage seem bright. The Society receives the support of a very large number of distinguished corresponding members in various parts of the world, and their assistance will naturally be very valuable in arranging for international action.

There is a need for more precise definition of the units, standards, terms and symbols used in illuminating engineering, and many difficult problems in scientific photometry still remain to be threshed out. These questions cannot be settled by any section of the lighting industry. They need the joint consideration of representatives of various systems of illumination. In 1908, when, at a meeting of the International Electrotechnical Committee, the question of the standards of light was discussed, the author proposed that the co-operation of bodies representing the gas industries should be invited, and it was agreed that this should be done. Since that time the principle of such joint action has been generally recognised. The need for international action on such points has already been responsible for the formation of an Illuminating Engineering Society in Germany, under the distinguished auspices of the Technisch-Physikalische Reichsanstalt of Charlottenburg, and with the support of the German Institutions of Gas and Electrical Engineers.

There are already in existence three Illuminating Engineering Societies in Great Britain, Germany, and the United States, and it is anticipated that a similar Society will shortly be formed in France. Already these societies have made provision for co-operation. But it is recognised that such co-operation should not apply only to purely scientific subjects and that important work might be done in connection with many problems of practical importance such as the measurement of light and illumination, the amount of illumination required in various indus-

trial purposes, &c. Naturally it would be a great advantage for the requirements in this respect to be the subject of international agreement.

The desirability of such common action has also been pointed out at a number of International Congresses at which the Illuminating Engineering Society was represented; for example, at the International Congress on Industrial Diseases (Brussels, 1910), the International Congress for the Prevention of Industrial Accidents (Milan, 1912), and at the International Electro-Technical Congress, held in Turin in 1911. At the Annual Congress of the Royal Institute of Public Health, held in Paris during the present year, a special section devoted to industrial hygiene was established for the first time, and in the discussion in this section, the consideration of industrial lighting played a prominent part. In the field of industrial lighting such congresses are already leading to far-reaching results. The French Government has appointed a committee on the hygiene of vision, and this year a similar committee, charged with the duty of inquiring into industrial lighting, has also been appointed by the Home Office in this country. It would naturally be a great benefit if similar committees could be instituted in all the chief countries, so as to work in co-operation and ultimately report at an International Congress on the subject.

Meantime the idea of an International Commission on Illumination, brought forward by the author at the International Electrotechnical Congress at Turin in 1911, has become an accomplished fact. Last month, at a conference held in Berlin, it was decided to form such a Commission by suitably enlarging the scope and membership of the Zürich International Photometric Commission, which was originally formed in 1900 in Paris, with a view to promoting researches on the photometry of gas.

National Committees on illumination will be appointed in all the chief countries and the statutes provide that in countries where Illuminating Engineering Societies already exist, these may assume the functions of the national committee—a step which would considerably simplify the problem of providing for adequate representation of all systems of lighting. The example set by Germany in this respect could with advantage be followed here in this country, where the Illuminating Engineering Society has already obtained recognition from the older and longer established institutions.

At the present moment it is impossible to predict the ultimate influence of this Commission, but we may be sure that it will have far-reaching and beneficial consequences to the lighting industries all over the world. The work of the whole illuminating engineering movement is such as to benefit all systems of lighting, as well as the outside public; we may hope that through its influence the jealousy and animosity between representatives of rival illuminants, already much modified by the events of the last few years, will gradually pass away.

It may be mentioned, also, that there are already many towns where both the gas and the electrical supply are owned by the municipality, and where it would be of great value to the authorities to have impartial information as to the circumstances in which the respective illuminants are best employed.

Your distinguished President, Sir Corbet Woodall, in his opening address, stated that this exhibition was "pro-gas," and not "anti-electric."

In the Illuminating Engineering Society the principle has always been to allow representatives of different systems of lighting to bring forward the claims of their own illuminants but to abstain entirely from attacking other systems. May we hope that this principle will be adopted far and wide throughout both industries, and that the energy frittered away in mutual enmity and interference will be replaced by a determined effort to work together in fields where both can benefit.

In the illuminating engineering movement, the author is convinced, there exists such a field. This has been fully recognised by the members of the Council of our Society, who, throughout its four years of existence, have worked together in an entirely friendly and harmonious manner.

It has been said that the best thing that ever happened to electricity was the introduction of the incandescent mantle; and looking at the matter

broadly, we can already see that the introduction of the metal filament lamp has likewise been a good thing for gas. In each case the step forward was a revelation to the general public of what abundance of light could do, and led to an upward leap in the standard of illumination. Moreover, experience has shown, again and again, that an advance in one system of illumination calls for a corresponding effort on the part of its competitors and saves them from sinking into an apathetic and lethargic attitude of mind. Illuminating engineering, by stimulating the demand for better light and raising illumination to a higher place in the public estimation, and by establishing an understanding as to what, exactly, the principles of good lighting really are, can do much for both industries.

In concluding this paper the author would, therefore, like to make a strong appeal to the members of the gas industry to come forward and support the movement in greater numbers.

We have before us an immense vista of useful work. We are making steady progress in the more technical aspects of illuminating engineering, such as the photometry of lamps, the determination of the polar curves of light distribution from globes, shades and reflectors, and illuminating engineering calculations—all of which are gradually permeating the lighting industry and are of great importance to those interested in the use of gas.

We hope also to establish gradually the standard of illumination required for various purposes and we are hastening towards the time when people will not think only of how much they can save off their lighting bill, but also will demand of a system of illumination that it shall be hygienic, artistic and supremely well adapted to their needs. Through the help of the architectural and the medical professions let us teach the public to appreciate good lighting, as a means of preserving eyesight and beautifying the home. Let us make it clear to the manufacturer, the merchant and the professional man that proper illumination is an essential element to the success of their work and that inefficient lighting appliances are dear at any price.

A piece of work on which the Society has already been engaged is the organisation of lectures on illuminating engineering. Such courses were recently held simultaneously at three institutions in London, the various subjects being dealt with by specialists in each department. It is hoped that in time to come such lectures will form an integral part of the courses of all the chief technical institutions.

A striking series of lectures of this kind was instituted at the Johns Hopkins University, Baltimore, U.S.A., under the auspices of the American Illuminating Engineering Society in 1910.

This leads the author to refer to the excellent pioneering work of the Society in the United States. In a lecture devoted to the aims of the British Society attention was naturally devoted mainly to European developments; but it should not be forgotten how much has been done in the United States since the starting of the Illuminating Engineering Society there in 1906. The author, in the course of his visit to that country in 1907, and again last year, had ample opportunities of judging the progress made.

In this paper, the author has not said much regarding the commercial aspect of lighting; this will be more fitly considered at a coming conference.

If the Illuminating Engineering Society were adequately supported it is scarcely possible to set limits to what it might accomplish. But in order to carry out its programme to the full a more generous measure of support is now desirable.

The problems on which it is engaged are of national importance, and there are several branches of its work which might well receive greater Governmental recognition and support.

LIGHT AND SIGHT.

By Meredith Young, M.D., D.P.H., D.S.Sc.; Officer of Health and Chief School Medical Officer, County of Chester.

(Abstract of Paper presented at the National Gas Conference and Exhibition on Friday, October 17th, 1913.)

Dr. Young commences with some remarks on the physiological structure and function of the eye and the physical causes of the sensation of light. Proceeding he details the suggestive researches of Prof. Mosso on the subject of fatigue with special reference to the eye.

It is important to note that besides the effect of insufficient or imperfectly shaded lights on acuteness of vision there is also the probability that such conditions may distract the attention and lead to *mental fatigue*. In this connection Dr. Young quotes the experience of Goethe that such fatigue persists longer in the case of enfeebled persons; and the "after-image" does not die away so quickly as in the case of healthy subjects. Another phenomenon following ocular fatigue is "hyperaesthesia," or increased sensitiveness to light. On the other hand, some people who habitually work in a very bright light seem to come to a condition of demanding an excess.

Prof. Mosso also describes a form of "ciliary cramp," or "spasm of accommodation," which may be caused by sudden exposure to a very bright light. But the most common result of fatigue is the myopia caused by the strain of close work, accentuated by the habit of bringing the print nearer and nearer the eyes, as the process of reading is found to become difficult.

The effects of excessive stimuli on the eye then receive attention from Dr. Young; such points as eclipse-blindness, results of exposure to short-circuit flashes or open electric arcs, mercury vapour lamps, snow-blindness, and other conditions where apparently ultra-violet rays are the directly responsible factors in causation are discussed at considerable length.

The effects of heat-rays are illustrated by the occurrence of cataract in glass-workers. Some observations have been made by Dr. T. M. Legge on this point. (It would be interesting to know under what conditions the heat radiated by a source near the eye is apt to cause trouble. Some authorities allege that illuminants differ in this respect. The effect of a strong light near the head seems to cause a dryness and irritation of the eyes, possibly due to the heat received). The properties of ultra-violet rays also require careful study, and it is specially desirable that their differentiation and standardisation should be attempted.

Dr. Young quotes from Steinmetz, Birch-Hirschfeld, E. Fuchs, Grimsdale, J. H. Parsons, and many others on this point. It is interesting to note that some authorities believe that the harm caused by exposure to an intense source may be due to a "power-blow" caused by the total radiation from a source, rather than by any particular quality of light. The important question of "glare" is very fully discussed, and experiments are described in illustration of the diminution in visual acuity following on exposure of the eye to glaring light-sources. Dr. Young makes frequent quotations from an article recently contributed by Dr. J. Herbert Parsons to *The Lancet* on this point. He also describes some experiments conducted by Dr. Cameron Gibson, which showed that a marked temporary fall in acuteness might be produced by staring at a bare lamp.

Dr. Young gives the intrinsic brilliancy of the chief modern illuminants and contrasts their brightness with the minimum permissible advocated by Bell (5 c.p. per sq. inch), and the still lower figures advo-

cated by Dr. Woodwell and Mr. Darch. One test of the effect of glare is the presence of the "after-image." In this connection the author remarks :—

The intensity of the action of light on the retina can be demonstrated approximately by the productions of fatigue or after-images. The thing can be easily tested (though in the case of the more brilliant lights the experiment is no pleasant one) by staring as steadily as possible at the source of light and then, in the darkness, finding out by means of an assistant, the duration of the after-image. The image tends constantly to fade away, but a flicker or blink of the eyelids causes it to reappear very bright for the fraction of a moment. The image from a 50-candle power Osram lamp is to my eye, at first yellowish, then reddish-yellow, then—somewhat suddenly—a beautiful violet and this drifts gradually into black: the lighter colours usually have a dark halo and the dark colours a light halo. Tested in this manner I found as the mean of a number of trials the following persistence of the after-image :—

50 candle-power Osram lamp (new) ..	3 min. 3 secs.
16 candle-power carbon filament (new) ..	1 min. 45 secs.
Inverted incandescent gas burner ..	1 min. 10 secs.
Wax candle (Price's), 16 to 1 lb. ..	33 secs.
Bryant & May's special (small) safety match	2 secs.

Further experiments are detailed demonstrating the loss of visual acuity occasioned by the presence of more or less bright lights in the field of vision though not directly impinging on the seeing part of the eye.

The mental effect (diminution of power of attention) of various lights and shades is next considered. Here again the effect of distraction comes in.

There are people who can work steadily in a din of noise, but the effect of surrounding brilliant lights seems to be often less easily shaken off. The conclusion is reached that for mental work adequate local illumination with somewhat less illumination of walls, &c., is most restful. Specific medical opinions of eye-specialists are quoted to the effect that :—

(1) The introduction of electric light has not led to the greater occurrence of eye-diseases or errors of refraction.

(2) That a brilliancy of 5 c.p. per sq. inch of lighting source is that which the eye can most comfortably endure.

(3) That working with insufficient light is a greater evil than working with sufficient (or more than sufficient) though unshaded light.

(4) That it would be to the advantage of workers if the use of unshaded lights of a greater intrinsic brilliancy than 5 c.p. per sq. inch of lighting surface were prohibited.

(5) That adequate and properly shaded local illumination is the best form of lighting for near work.

Dr. Young then passes to a review of the advantages and disadvantages of gas as compared with electric light. He disbelieves the statements usually made as to the polluting effect of gas on the atmosphere, and gives it as his opinion that there is no truth worth considering in the carbonic acid theory; but that there is some vitalising constituent in fresh as compared with polluted air, the nature of which has not yet been discovered. From the hygienic point of view there is nothing to choose between gas and electric light. So far as the eye is concerned the risk is greater from electric light than from gas. Investigations are needed, by which deterioration of internal decorations by gas could be rendered easily preventable.

The principal faults of artificial light are enumerated and the chief of these discussed in detail. Finally, Dr. Young passes to the consideration of the lighting of factories, schools, hospitals, dwelling-houses and shops. He puts in a strong plea for further and better attention being given to the case of the clerk in particular who, he states, seems to have almost altogether escaped protective legislation.

In connection with factory lighting, he remarks :—

How often is an illuminating engineer called in to advise about a lighting scheme for any building? Yet illuminating engineering work, though young in the field, has made strides which leave ventilation engineering centuries behind and a sound illuminating engineer can not only save pounds in initial and subsequent cost, but can materially assist in the conservation of eyesight.

In the case of schools he discusses some of the findings of the Special Committee recently appointed by the Illuminating Engineering Society, and urges that a somewhat higher standard than recommended by the majority of that Committee is desirable. The relative advantages and disadvantages of direct, indirect, and emi-indirect methods of lighting as used in schools are concisely summarised; semi-indirect lighting appears to appeal most strongly to Dr. Young, though he names certain common faults of this system which are capable of easy rectification.

For school lighting the three systems, direct, indirect, and semi-indirect, appear to possess the following advantages and disadvantages :—

	Advantages.	Disadvantages.
Direct	Easy to arrange for a considerable amount of light reflected on to the working plane. Broken fittings easy to replace. Reflection from shining surfaces not marked if units well distributed. Energy consumption low.	Dust and dirt apt to collect on fittings. If too few points installed or these placed too low disconcerting shadows are caused. Shimmer due to reflection from paper marked, unless units placed high up.
Indirect	Perfect relief from glare. Shimmer from paper absent. Harmful shadows avoided.	Energy consumption comparatively high. Bright reflection from walls and ceiling physiologically undesirable. Spares not always readily available. Very difficult to arrange for an adequate amount of light to be reflected on to working plane.
Semi-Indirect	Adequate relief from glare. Shimmer from paper present though almost negligible in amount. Harmful shadows rare. Easy to arrange for an adequate amount of light on working plane.	Energy consumption about the same as for direct lighting. Bright reflection from ceiling and walls much less than with indirect methods though still present.

Dr. Young criticises strongly the methods commonly employed in lighting hospitals and urges the employment here, as indeed in all establishments where adequate and comfortable lighting is of consequence, of an expert in illumination.

The prevalent inadequate lighting of kitchens, sculleries, and butlers' and housemaids' pantries, constitutes a very real hygienic danger. From the disease-prevention point of view these should undoubtedly be the best-lighted parts of any house.

Dr. Young regards it as economically unsound policy to create light sources of immense candle-power and then to interpose shades, globes, and reflectors to mitigate any possibly injurious effects. The real issue between gas and electric light has been narrowed down to one of cost, and provided the service was adequate and hygienic the public must be guided by the bill they are called upon to pay.

THE ECONOMY OF EFFICIENT LIGHTING.

Good Lighting as an Aid to Increased Output and a Safeguard against Accident.

By Franklin Thorp.

(Abstract of Paper Read at a Conference on "Some Aspects of Scientific Illumination," at the National Gas Congress and Exhibition, on Friday, 17th October, 1913.)

In the introduction to his paper Mr. Thorp referred to the honour conferred on the Conference by having Lord Rayleigh in the chair, and to the papers just presented by Mr. Leon Gaster and Dr. T. Meredith Young.

The two chief requirements in industrial lighting were the provision of sufficient industrial illumination and the avoidance of glare. The latter may be illustrated by reference to the experience of a pedestrian encountering the searchlight of a motor car on a dark night.

People have begun to be impressed by the need for good illumination on hygienic and scientific grounds, but an infinitely stronger argument with manufacturers is the question of £ s. d. We may take it as a truism that shops which are badly lighted cannot possibly turn out the best class of work, and that the trades requiring the most careful examination are the first to appreciate the value of proper illumination.

The Lancashire factory master in general is keen to recognise the value of anything that will increase his turnover or the quality of his goods, and for many years the provision of proper access of daylight has been carefully considered in the construction and design of mills. A common arrangement is a series of "inverted saw-toothed" panes having a very large glass area. Yet the importance of good artificial illumination, which is surely equally great, is still insufficiently realised. Mr. Andrews, General Manager of the Gas Department at Oldham, recently took a census of the burners in the works of mills of that city, and was surprised to find that there were still 49,436 flat-flame burners in use. A series of tests in 18 mills recently showed an average maximum of 32 foot-candles and a minimum of 8·6 foot-candles by daylight as compared with 0·62 foot-candles with flat flame burners and 0·58 to 1·2 foot-candles with carbon filament electric lamps. This shows the need for reform. Mr. Franklin Thorp declares that there is no reason why these out of date and inefficient illuminants should be used in mills, now that so many more efficient methods are available. Many thousands of inverted incandescent burners are being installed yearly in Manchester, and by this means as much as 6—8 foot-candles can be obtained on the loom. These sources are equipped with suitable reflectors and are commonly placed 6 ft. 6 in. high.

Fig. 1.—Illumination of drawing-in or twisting in frame by local shaded light.

Experience shows that not only does this improved illumination pay handsomely by leading to better work and improved output, but the workers are more contented. Many cases have been known of weavers leaving one firm to go to another simply on account of the improved illumination, and in one or two cases a strike has only been averted by hurrying on the lighting of a shed!

It is difficult to get details of the improved output from manufacturers, but a rough criterion is the amount of wages paid to weavers. Thus in one of the best-lighted mills the wages for the ten weeks ending December 18th were £2,498, and for the ten weeks ending October 9th £2,941, showing that in spite of the diminished daylight the turnover was equal to that during the summer months. Probably in a badly lighted mill the turnover would be decidedly less.

But another point to be considered is the quality of the work. In a modern mill a woman would probably attend to 3 or 4 looms. Now each loom has a shuttle which works at about 200 picks per minute, the warp in the loom averages some 2,500 threads in a space of 28 inches and the shuttle must pass through this 200 times a minute. If one of these 2,500 threads breaks for any length of time the broken thread would get entangled with others and would cause a general breakage and stoppage. It is therefore well worth while to provide a good illumination such as would enable the worker to detect any such mistake at the earliest possible moment.

It is a striking fact that the cost of lighting in mills is usually a very small proportion of the wages. For example, Mr. Thorp mentions a mill where the lighting costs are only 0·2 per cent. of the wages bill, so that it requires very little extra turnover to pay for the improved lighting many times over. (The Insurance Act provision comes out to 0·36 per cent.—nearly double the lighting cost.) It is singular to notice how two weavers working side by side will vary greatly in skill, one weaver earning 25 to 30 shillings, while the other never earns more than 21 shillings a week. Such differences make it difficult to compare accurately results in various mills; but it is unquestionable that the conditions of illumination will have a decided effect on the amount of work that can be done, and the money earned.

In conclusion, Mr. Thorp refers to some of the tests carried out by Mr. D. R.

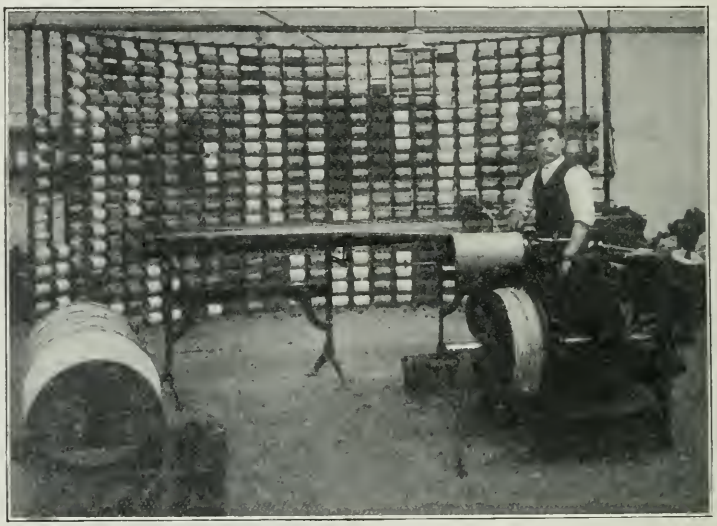


Fig. 2.—Showing the complicated series of hundreds of bobbins of various shades and colours, and the large number of threads in a sectional warping frame. Here good general illumination is absolutely vital.

Wilson and his recommendations on factory lighting. In mills where there is machinery in motion a medium gas pressure is preferable to a very high one. Mr. Thorp recommends three inches pressure at the meter raised by compression to 12 inches in the building. This would enable a fairly good light to be obtained even if the compressor stopped—a matter of great importance as many accidents have occurred through sudden light failure whilst the machinery has been in motion.

Another matter of consequence in mills is avoidance of the burner being choked by particles of dust or fluff. One method of avoiding this is to provide a burner with a mixture of gas and air prepared at the compressors, so that little of the external air carrying fluff and dust enters into the burners.

In conclusion, Mr. Thorp refers to some instances of accidents owing to insufficient lighting. By the courtesy of the Federation of Master Cotton Spinners he has obtained the number of accidents occurring in spinning and weaving departments during the various months of the year. The statistics are affected by the progressive increase in the numbers of looms and shuttles at work, but it is interesting to note that there is clear evidence of a tendency for more accidents to occur during the dark months, and that during the period March to August a distinct decrease in the number of accidents occurs.

[We propose to deal with the papers presented at the Conference of Manufacturers on Oct. 29th, in our next number.—Ed.]

SOME NOTES ON THE LIGHTING OF THE IDEAL HOME EXHIBITION,

By an Engineering Correspondent.

Good illumination is surely an essential in "the ideal home," and lighting should naturally play a part at an exhibition bearing this name. Last year reference was made to the arrangements at a similar exhibition held at Olympia. It was pointed out that in many of the model houses shown the lighting arrangements were attended to in a rather casual manner, bare filaments in shallow "crinkly" glass shades being common.

It must be owned that a similar criticism might again be levelled at much of the lighting at this exhibition, both in the model houses and on many of the stalls. The standard of lighting in the latter, however, is uneven. In some cases bare lamps were much in evidence; in others concealed lights, semi-indirect methods and ornamental shaded table lamps were tastefully employed. In the toy section in the galleries, one found rows of stalls lighted on a uniform system by 3-light pendants carrying exposed lamps; while a little further on rows of concealed lamps were used for stalls of a very similar kind. In the latter case proper reflectors were not as a rule fitted to the lamps, and this impaired what might otherwise have been a good effect.

On the ground floor, however, there were quite a number of tasteful displays, silk lampshades carrying Chinese and other patterns, and rooms decorated in French, Dutch and other styles, and having lighting fixtures of the same period. There were also quite a number of stalls devoted to lighting appliances. The South Metropolitan Gas Company had a large stall, equipped with various types of shades, and having round it a circle of inverted burners in Holophane reflectors, and there were also various petrol air gas systems in evidence.

The item attracting most attention was undoubtedly the "Maison Electrique," exhibited by the Electric Supply Publicity Committee. A queue was in continuous process of formation, and it was stated that as many as 15,000 people passed through the house in one day.

The miniature garden entrance was graced by a playing fountain illuminated from below with changing colours, and the house contained reception room, dining room and kitchen, all heated and lighted by electricity. Examples of direct, indirect and semi-indirect fittings were on view. The dining room was, perhaps, over-lighted, but no doubt this was considered necessary to attract attention.

This room was the chief centre of interest, the table being equipped with floral decorations with miniature lamps concealed in them, and an ingenious "railway and lift" service "by which a complete dinner may be served from below without the visible intervention of servants." The way the dishes popped up through the hole in the table was a constant source of entertainment to visitors.

As regards the general lighting of the exhibition, it may be noted that the arc lamps are now concealed in iron-work baskets, giving a somewhat original, imitation antique effect. In the Russian Village, however, the flame arcs shone unadorned, and the brilliant lighting by metallic filament lamps in some of these externally humble village buildings also struck one as out of keeping with the surroundings.

Reference has been made above to the idea of showing rooms decorated in a certain style and illuminated by lighting fixtures to match—a very effective form of exhibit. In some of the rooms in the gallery some highly novel modern efforts were shown. In one case the sole source of light was a lamp concealed behind a gilt decoration over the mantelpiece. In the "Moonlight Sonata" room a striking scheme of decoration in dark green and grey, with grey metal pedestals and lilies, was used; the sources of light being two antique, but gracefully formed oil-lamps in the corners.

There were also rooms done in the Watteau, Russian and other styles. In several of these, also, exceptional use of light for pictorial or symbolic effect was made. In such cases the lights and decoration should be regarded as forming a picture—an artistic creation—rather than as exemplifying an actual living room. In most instances the light derived from the illuminants in the room would not have sufficed to show it off properly, and concealed lights in the foreground, not forming part of the picture and having the functions of footlights on the stage, had to be employed.

The Illuminating Engineering Society.

(FOUNDED IN LONDON, 1909.)

OFFICIAL ANNOUNCEMENT OF FIRST MEETING OF THE SESSION

(To be held in the House of the Royal Society of Arts, 18, John Street, Adelphi, London, at 8 p.m. on Tuesday, Nov. 18th, 1913.)

At this meeting the Hon. Secretary (Mr. L. Gaster) will present a short report on **progress during the vacation,** and Mr. F. W. Goodenough (Chairman of the Council), and Dr. James Kerr respectively will give some account of the proceedings at **The National Gas Exhibition** and **The Fourth International Congress on School Hygiene,** held at Buffalo during last September.

Subsequently a series of photographs illustrating **Shadow Effects by Natural and Artificial Light** will be presented by Messrs. J. S. Dow and V. H. Mackinney.

INDIRECT AND SEMI-INDIRECT ILLUMINATION IN A SMALL HOUSE.

By an Engineering Correspondent.

A great deal is often made of the possibilities of semi-indirect and indirect lighting for large halls and mansions. But it is perhaps hardly sufficiently recognised how convenient such methods often are for the lighting of quite small rooms. The illustrations showing the value of this method in a suburban villa may therefore be of interest.

Figs. 1 and 2 illustrate the use of semi-indirect lighting in a drawing room which is approximately 19 ft. long and 12 ft. broad. It is completely lighted by a single alabaster bowl containing three 20-watt lamps. The illumination in the centre of the room is about 1·8 foot-candles, and in the far corners is still above ½ foot-candle. Over one foot-candle is available over all parts of the room where reading may be necessary; and from the artistic standpoint the gradual diminution of illumination from the centre of a drawing room to the walls seems to be considered correct.

A small room can thus be lighted quite well by a single central unit. The consumption of electricity in this case is less than ⅓ watt per sq. ft. In a larger drawing room it would doubtless be necessary to use wall brackets as well as a central unit in order to prevent the illumination falling too low near the walls; too dimly-lighted corners give a rather dismal effect. The consumption in such cases would necessarily be somewhat less. The use of wall brackets is not an economical method, and, being so near th eye-level, the lights have to be managed rather judiciously in order to avoid glare. (It is a common error in such brackets to use lamps of too high candle-power; 10–15 c.p. would often be sufficient.) In a small room, therefore, a single central semi-indirect unit may be

Fig. 1.—Drawing Room lighted by a single central alabaster semi-indirect unit.

conveniently applied, especially if the walls are fairly light. In this case provision has also been made for standards or portable lamps by appropriate wall plugs. The illustrations show that the diffusion of light is good and yet the degree of contrast is quite sufficient to give the room a cheerful appearance. The following average surface-brightness values may be of interest:—

Surface of alabaster bowl, 80 f.c.
Ceiling, brightest central portion, 8 f.c.; edges, 1 f.c.
Walls, 0·2–6 f.c. (near fireplace).
Carpet, 0·05 f.c.

A point still to be determined for semi-indirect lighting is the desirable ratio between the brightness of the bowl and that of the ceiling; one would also like to know the best relation between the brightness of walls and ceiling. In this case the installation complies excellently with Weber's recommendation for the avoidance of glare, *i.e.*, that the ratio between the brightest object and its background should not exceed 100 : 1. For the surface lighting of the bowl is only 80 times the brightness of the darkest part of the ceiling, and its absolute value is only 0·2 c.p. per sq. in. (approx.)

Fig. 3 (see p. 577) shows a novel indirect lighting fitting in use in the dining room of the same house. Here again the light is provided by a single central fitting containing eight 20-watt lamps. The horizontal illumination in the room is 1·8–2·4 foot-candles—decidedly more uniform, therefore, than in the drawing room. The consumption of electricity works out to about 0·6 watts per sq. ft.

The surroundings in this room are distinctly dark, compared with those in the drawing room. The wallpaper is brown and even the ceiling carries a pattern and is not, strictly speaking, a "dead white." In the circumstances, the diffusion of the light is good—in a sense *too good*, since the general effect shows rather insufficient contrast. In this room double switching, enabling four lamps to be used at a time, was provided: but in order to give the room a cheerful appearance it is found necessary to have all the eight lamps on simultaneously.

The range of brightness is somewhat less than in the drawing room, as the following figures show:—

Surface brightness of ceiling:—

Centre	30 f.c.
Edge	2 ,,
Surface brightness of white frieze	1·8 ,,
,, ,, brown wall-paper ..	0·5 ,,
,, ,, oak mantel-piece ..	0·08,,
,, ,, carpet ..	0·2 ,,

The shape of the indirect fitting, which is built up of lamps in trough reflectors, is novel and has some advantages over the usual bowl type. The fact that the illuminated ceiling can be seen through the aperture in the centre of the fitting seems to remove the impression of "flatness" sometimes complained of in indirect installations, and gives a lighter, more dainty effect than a solid bowl silhouetted against a white ceiling.

Indirect lighting is somewhat unusual in a dining room, where the ideal method is generally considered to be a moderate general illumination supplemented by strong local lighting on the table by a well-shaded central unit. This view is doubtless the correct one to take in a comparatively large house where the dining room is rarely used except for meals. But in a small house, where it is probably used for reading and writing as well, indirect and semi-indirect methods have their uses. Another point to be noted is that in small rooms the introduction of armchairs beside the fire often leads to the table not being central. In this case a low-hanging lamp is apt to come over the chairs on one side of the table, instead of over the centre—an absurd arrangement that is readily obviated by using an indirect fitting hung near the ceiling.

In conclusion a few words may be said regarding the photographs accompanying this article. These are taken entirely by the actual light in the rooms, and are not retouched in any way. The conditions of exposure and development were regulated with a view to reproducing the actual appearance of the interior.

But the conditions illustrated in the short note following this article show that photography, besides being capable of faithfully portraying the real appearance of an object, can also be used to produce an entirely false effect.

FIG. 2.—Another view of the Drawing Room lighted by a single semi-indirect alabaster bowl unit. The consumption of electricity is about $\frac{1}{3}$ watt per sq. ft.; the illumination 1·8 ft.-candles under the lamp and 0·5 ft.-candle near the walls.

(Natural Photograph taken by Artificial Light).

DAYLIGHT AND NIGHT—WHICH IS WHICH?

THE two photographs shown below were taken outside the house referred to in the previous article.

The picture on the left was taken in broad daylight—that on the right at dusk.

The photographs have not been retouched in any way. No flashlight was used and the pictures were taken merely by the light prevailing in the street at the time. All that has been done is to adjust the exposure and development so as to make the pictures as much alike as possible. On close examination a shadow on the roof of the house on the left shows that this picture was taken in full sunshine. Similarly the fact of the lights being visible in the hall and through the windows in the right hand view suggests that this was taken in the night-time. Otherwise the pictures might both equally well have been taken in daylight. The night photograph, of course, reveals a great deal that was actually indistinguishable to the eye.

These two illustrations may be of interest as showing what widely different results can be obtained in photography, even when the picture is taken without such extraneous aid as flashlight, and there is no retouching. Photography, wisely used, can render invaluable aid in contrasting different conditions of lighting.

View by full daylight.

View taken at dusk.

But the above illustrations show that some discretion should be used in interpreting photographs professing to illustrate the appearance of an interior "before and after" a certain system of lighting is installed. In all such cases one would like to have confidence that the problem has been treated in an impartial manner, and that a conscientious effort has been made to represent conditions as they really are.

FIG. 3.—Dining Room lighted by novel form of indirect unit. (See p. 574.)
The use of a square frame with central aperture helps to relieve the black appearance of a solid object seen silhouetted against a bright ceiling.
(*Natural Photograph taken by Artificial Light.*)

LIGHTING OF A PHOTOGRAPHIC DARK ROOM.

It is rather odd that photographers —very careful people in many respects— are apt to lose sight of the importance of suitable lighting in the dark room. The ruby lamps are carefully selected for safety as regards their effect on plates; but very often little attention is paid to the way the light is distributed.

It is decidedly inconvenient in a dark room to be unable to see an inch before one's nose, and to have to grope for bottles in the dark; and it is usually unnecessary. A dark lamp can be arranged to give a good light by which to watch development and also to throw sufficient illumination about the room, without danger of fogging ordinary types of plates.

The device shown in the illustration is one suggested method of dealing with the problem. It consists in a box, having a whitened interior, and a diffusing white glass plate in front. It is open at the top. It contains two lamps, one white and one ruby, controlled by the two-way switch at the side of the box. By this means the operator can immediately change over from red to white light and flood the room with light when it is safe to do so.

The filaments are completely screened from the eye and the illuminated white glass plate makes an excellent background for the inspection of negatives. The fact of the box being open allows a considerable amount of light to strike the white ceiling and walls; this diffusion is very useful in illuminating all parts of the room. The photograph shows that shelves, bottles and sink are all quite sufficiently visible.

SHORT NOTES ON ILLUMINATING ENGINEERING.

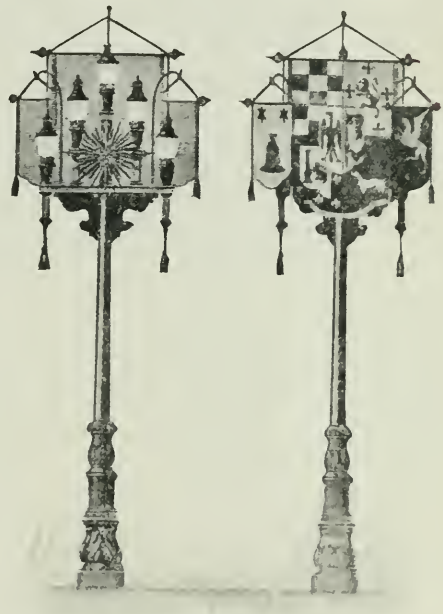
ILLUMINATED BANNERS AT THE PANAMA EXHIBITION.

From time to time we hear rumours of the vast scheme of lighting being arranged at the forthcoming Panama Exhibition.

In *Popular Mechanics* an account is given of some illuminated banners which will form a novel spectacular device. Luminous arcs mounted on standards 55 ft. high will illuminate canvas banners, eight feet across, as shown in the illustrations.

The sides of the banners are to be boxed in with white canvas, thus diffusing the light and giving an even illuminated surface and throwing the emblematic device into a soft glow.

It is stated that thousands of these banners will be used.



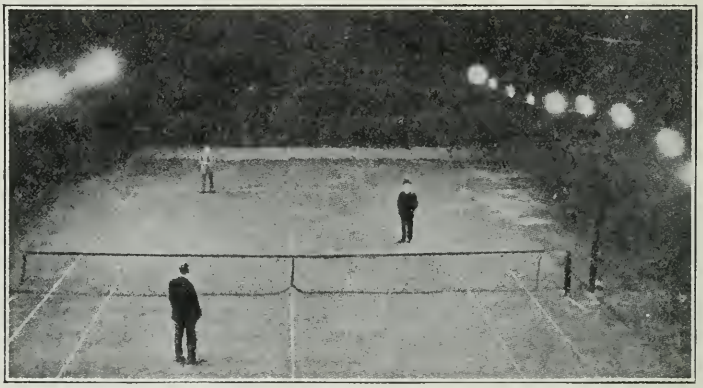
LANTERNS ON RAFTS.

According to the *Electrical Review* (Chicago) the government regulations, log-rafts on the Columbia River (U.S.A.) —unquestionably the largest rafts in the world—can only be towed down by night. During the day their passage would interfere too much with the ordinary navigation on the river.

The rafts must therefore be equipped with lights fore and aft. Small 4 c.p. tungsten lamps are used for the purpose. They receive current from an accumulator having a capacity of 100 amp.-hrs., the cell being slung on ropes at a considerable height above the raft so as not to be affected by the wash of heavy seas.

ANOTHER ELECTRICALLY LIGHTED LAWN TENNIS COURT.

We see in the *Electrical Review and Western Electrician* an account of the electric lighting of an out-door gravel lawn tennis court in Chicago. In this case (as in the Liverpool covered court described in our last number) the lamps are placed at the side of the court, twenty-four 250-watt tungsten lamps being employed.



The lamps are equipped with white enamelled reflectors and are slung on wires carried along the sides of the court 12–13 ft. above the ground. The consumption of electricity is approximately 1·2 watt per square foot.

The court is said to be in constant demand in the summer evenings. The cost of the installation was $250 and the expense of lighting the court amounts to about 60 cents (2s. 6d. roughly) per hour.

CONGREGATION SUMMONED BY ELECTRIC LIGHTS.

According to *Popular Mechanics*, a church in Chicago is using powerful arc lamps instead of bells, in order to summon the congregation to evening worship. The arcs are fixed on the top of the church steeple so as to be visible from afar.

Besides announcing the beginning of the service these arcs are kept burning while it is in progress so as to attract the notice of late comers and let them know that there is "something doing."

This is yet another instance of the *eye* being used in place of the *ear* as a means of conveying information. Some caution would seem necessary as regards the intrinsic brilliancy of these lights. People sometimes complain of the offence to the ear of innumerable chiming bells. Are these to be replaced by the shock to the eye of innumerable strong lights ?

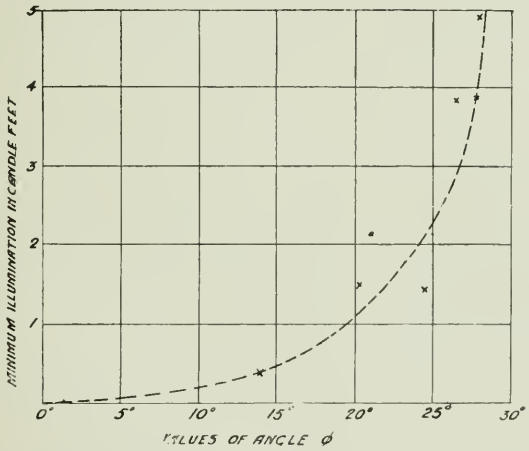
CORRESPONDENCE.

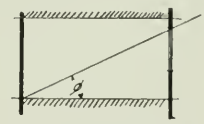
NATURAL LIGHTING OF SCHOOLS.

SIR,

All who are interested in the fascinating problems of daylight illumination will welcome the evidence of careful investigation shown in Dr. Gibson's Report on the Cheshire Schools, summarised on page 449 of your October issue. But I venture to point out that the value of much of the data acquired is vitiated by inconsistencies, probably due to the fact that, whereas the inside illumination was measured with a photometer, the outside illumination existing at the time when the record was made was measured by the effect upon photographic paper. The latter is peculiarly sensitive to light from blue sky, which is an extremely poor agent for lighting interiors. Unless measurements of the daylight illumination in rooms can be accurately co-ordinated with the outside illumination upon which it depends such measurements are practically useless.

As an example, Cases 4 and 5 in the table are evidently similar rooms in the same school, the ratio of glass to floor area, the height of window and its distance from the back wall, are all identical and the measurements were taken within an hour of each other. The second observation of the outside daylight shows a drop from 3 to 1, whereas the inside illumination only fell from $2\frac{1}{4}$ to 1, the blackboard illumination only fell from $1\frac{1}{2}$ to 1, and the maximum actually rose. I have endeavoured to average the results in cases where one actinometer value and one height of window are given by raising or reducing all the minimum illuminations so as to be consistent with an actinometer value of 50 (as suggested in the Report), and with a ratio of glass to floor area of 1, and plotting the minimum illuminations as ordinates against the angular height of glass above floor as abscissæ.





One cannot, of course, rely on the accuracy of any one result, but the average curve drawn through the result is precisely what one would expect from experiments in the relative values of light from different angles.

The most significant item in the Table is No. 20. This case, in which the light

was nearly vertical, is the only one where the minimum illumination was over 16, and that with an actinometer value which, according to the Report, approximated to "weak wintry sunshine." As the noon altitude of the sun on 26th November, 1912, was 17° 33′, the room could not have been receiving direct sunlight from a roof light.

Yours faithfully,
PERCY J. WALDRAM.

POLAR CURVES OF GLOBES, SHADES AND REFLECTORS.

DEAR SIR.

As you truly remarked in your last number, the present lighting season is being heralded by great activity in the design of globes, shades and reflectors; and nothing is more striking than the importance which manufacturers now attach to illuminating engineering. Many firms are publishing polar curves of light distribution with their lamps and shades who, a few years ago, would never have done so.

There is one point to which I should like to draw attention. It is most essential that published polar curves should be accompanied by an explanation how they are obtained, so as to avoid the results being misinterpreted.

It seems therefore that it would be a great gain if manufacturers would agree to have tests made of their typical shades at some central institution such as the National Physical Laboratory, and to publish the certificate received. We should then have available authoritative information, and surely such data would carry much more weight than the record of the tests undertaken by the manufacturers themselves.

I am,
Yours, &c.,
AN ENGINEERING CORRESPONDENT.

PUBLICATIONS RECEIVED.*

Das elektrische Licht im Dienste der Projektion. By N. A. Halbertsma. (Paper read at the General Meeting of the "Bund deutscher Handler für photogr. Bedarf." September 22nd, 1912).

Mercury Vapour Converters. By Maurice Leblanc, Jr. (Reprinted from "The Electrician," July 18th, 1913.)

Light and Art; the Influence of Coloured Surroundings on the Colour of the Useful Light; Investigation of Diffusing Glassware; a Colour Triangle for Lecture Purposes; Factors involved in the Flicker Photometer; the Purkinje Effect and the Comparison of Flicker and Equality of Brightness Photometer. The Importance of Direction, Quality and Distribution of Light. (Papers by Mr. M. Luckiesh, reprinted from various Journals in the United States.)

The Mechanical Engineer and Prevention of Accidents. Address of Mr. John Calder, M.E., before the American Society of Mechanical Engineers, February 14th, 1911.

G. F. Schaar's Kalendar für Gas- und Wasserfach, by Dr. E. Schilling (R. Oldenbourg, Munich, 1913.)

Electric Circuit Theory and Calculations by W. Perren Maycock (Whittaker & Co., London, 1913. 3s. 6d. net.)

Das Städtsche Gasrohrnetz, seine Berechnung, sein Bau und Betrieb, by P. Brinkhaus (R. Oldenbourg, Munich, 1913. Mk. 5.)

Sur les Elements qui charactérisent le facteur de puissance des fours à carbure de calcium, by L. Lombardi and O. Scarpa. (Paper presented at the VIIth International Acetylene Congress.)

* To some of these publications we hope to refer more fully shortly.

REVIEW OF THE TECHNICAL PRESS.

ILLUMINATION AND PHOTOMETRY.

THE series of papers read at the National Gas Exhibition, and also at the Annual Convention of the American Illuminating Engineering Society last month are referred to elsewhere in this number.

There have been several other communications of interest in the United States. An abstract of the presidential address before the American Illuminating Engineering Society from MR. P. S. MILLAR is now available (*Am. Gaslight Jour.*, Oct., 1912). The paper contains a series of **statistics bearing on the lighting industry.** In the last six years the approximate average c.p. of incandescent lamps sold has almost doubled. Other data are available regarding the illumination in railway carriages, which appears to have increased no less than six times what it was about 40 years ago. Particulars are also given of the illumination now customary in streets, offices, factories, &c. The latter part of the address contains a general discussion of such points as diffusion, contrast, hygiene and safety, &c.

M. LUCKIESH in a paper now published in the *Gas Institute News*, discusses the **effect of the direction, quality and distribution of light.** Some interesting illustrations are shown. One of these shows the difference in appearance of a picture according to the direction from which the light strikes it; another the distortion of colour that may be caused by the tint of the illuminant. Several photographs illustrate the change in appearance of casts and statuary when illuminated from different directions. The expression on a man's face may thus be entirely altered. Another series of papers by L. C. PORTER, C. R. SUGG AND A. R. DENNINGTON (*Elec. World*, Oct. 11th), deal with the **design of motor-car headlights.** The authors point out the change in conditions of design brought about by the coming of low voltage incandescent lamps having filaments coiled in a spiral occupying a smaller area. Charts and data are presented enabling the sweep of the searchlight corresponding with various foci for the lens system, and contours of equal illumination on the roadway sketched out.

Turning to more purely photometric matters we may note the article by J. S. FORREST (*Electrician*, Aug. 8th) on the **electric arc as a standard of light.** The author proposes to use two carbons inclined towards a third one in order to obtain a steady arc, and the crater is observed through a hole 1 millimetre in diameter. It is said that a very constant brilliancy is thus obtained, and that the current taken by the arc can be varied within wide limits without much affecting the candle-power. The light is, however, somewhat affected by the purity of the carbons, and the hole must be very accurately measured.

H. C. STEVENS (*Phil. Mag.*, July, 1913) describes some experiments on the flicker photometer which show that the sensation of flicker cannot be due to changes in the iris diaphragm; a comparison of results obtained with normal vision and an eye, the pupil of which has been artificially dilated by atropine, shows that substantially the same effect was obtained in each case.

Electric Lighting.

A rather curious effect is described by O. COSMANN (*L. u. L.*, September 25th) who ascribes the frequent **breakage of filaments in coloured globes** to the electrostatic attraction between the filaments and the lacquered bulb of the lamp. It appears that in coloured lamps the effect is accentuated by the presence of a thin film of air between the glass and the lacquer which acts like a condenser.

A. KASTALSKI describes the lighting of the front of the chief railway station in Leipzig by arc lamps. This is accomplished mainly by iron columns which serve to support the trolley wires of the tramways. There is also an illustration

containing two novel ornamental pillars, cased in stone 30 meters high, and each carrying four arc lamps.

A comprehensive paper by M. SOLOMON on **yellow flame arcs** has recently appeared in the proceedings of the Institution of Electrical Engineers (Vol. 49, p. 737). The author classifies the general types of flame carbons now in use, and discusses the various methods of reducing their resistance. It appears that coating of the outside of the carbon with copper is likely to be discontinued because it gives rise to irregular burning; it is preferable to use a metal core. The remainder of the paper is devoted to polar curves, tables of c.p., the results of tests of a number of well-known types of arc lamps being given.

Gas Lighting.

The gas journals in this country are naturally devoted very largely to the Exhibition at Shepherd's Bush.

Among other articles we may notice the account of **billposter lighting** now being undertaken by the South Metropolitan Gas Co. (*J. G. L.* Sept. 30th). The posters are illuminated by lamps having specially shaped reflectors; it is probable that this business will extend as people come to realise the value of illuminating advertisements by night.

The *Gas Institute News* contains a fully illustrated article by C. A. Luther, describing the **gas lighting of interiors.**

The first part of the paper deals with office organisation. Plans of interiors accompanied by full particulars, as the colour of the walls and ceilings, &c., are prepared before the lighting of buildings is schemed out. A number of novel semi-indirect gas fittings are shown, and the lighting of the drawing room, dining room, kitchen, &c., are in turn briefly dealt with. One feature described in some detail is a form of dome lighting appliance for the dining room table. The latter part of the paper is devoted mainly to office lighting, and a number of illustrations are given showing the spacing of the units.

In the German papers we notice an account of the **high and low pressure lighting at Cologne** (*J. f. G.*, Oct. 18th), and the same journal contains an illustration of a new form of signal lamp which is being put up at level crossings to warn travellers against the trains. This is equipped with dissolved acetylene, a flashing valve being used to reduce gas consumption.

LIST OF REFERENCES:—

Illumination and Photometry.

Dennington, A. R. Considerations in the Design of Headlamp Light Sources (*Elec. World*, October 11th).

Dickinson, W. S. Graphic Solution of Illumination Problems (*Elec. World*, September 20th).

Editorial. Efficiency of the Eye under difficult Systems of Illumination (*Elec. Rev. & West. Electrician*, October 4th).

Forrest, J. F. The Electric Arc as a Standard of Light (*Electrician*, August 8th).

Luckiesh, M. The Importance of Direction, Quality and Distribution of Light (*Gas Institute News*, September).

Millar, P. S. The Status of the Lighting Art (Abstract of Presidential Address before the Am. Illum. Eng. Soc., *Am. Gaslight Jr.*, October 13th).

Porter, L. C. Performance of Incandescent Headlamps (*Elec. World*, October 11th).

Stevens, H. C. The Flicker Photometer and the Iris (*Phil. Mag.*, July).

Sugg, C. R. Principles of Headlamp Illumination (*Elec. World*, October 11th).
The Architect and the Electrician (*Elec. Rev.*, October 10th).
The Illuminating Engineering Society Convention (*Elec. World*, September 27th).
Internationale Beleuchtungskommission. (*J. f. G.*, September 27th; *Elek. u. Masch.*, September 21st).
Value of Proper Show Window Lighting (*Elec. World*, October 4th, 1913).
Park and Boulevard Lighting in Chicago, (*Elec. Rev. & West. Electrician*, September 20th).

Electric Lighting.

Cosmann, O. Ueber die Zerstörung der Fäden in gefarbten Glühlampen (*L. u. L.*, September 25th).

Editorial. Incandescent Headlamps (*Elec. World*, October 11th).
Incandescent Lamp Advances (*Elec. Review & Western Electrician*, October 4th).

Kastalski, A. Die Bogenlichtbeleuchtung des Vorplatzes des Hauptbahnhofs im Leipzig (*E. T. Z.*, October 9th).

Solomon, M. Yellow Flame Arcs (*Jour. Inst. of Elec. Engrs.*, Vol. 49, p. 737).
Electric Equipment of a Department Store (*Elec. World*, September 20th).

Gas, Oil, Acetylene Lighting.

Babcock, C. B. Why the Gas Company should handle Gas Arcs (*Am. Gaslight Jour.*, September 29th)

Luther, C. A. Gas Lighting of Interiors (*Gas Institute News*, September).

Offe, —. Pressgas und Niederdrück Starklicht-Beleuchtung in Köln (*J. F. G.*, October 18th).

Sproxton, K. More Light (*G. W.*, October 4th).
The National Gas Exhibition (*J. G. L.*, September 30th, October 7th, October 14th, October 21st; *G. W.*, October 4th, 11th).
Railway Carriage Lighting (*J. G. L.*, September 30th).
Bill Posting Station Lighting (*J. G. L.*, September 30th).
High Pressure Gas Lighting at Edinburgh (*J. G. L.*, October 14th).
Neue Schwachstrom-Fernzündung (*J. f. G.*, September 27th).
Signallampen zur Markierung von Eisenbahnübergangen auf Landstrassen (*J. f. G.* October 4th).
L'Éclairage des Passages au Niveau (*Rev. des Eclairages*, September 30th).

CONTRACTIONS USED.

Elek. u. Masch.—*Elektrotechnik und Maschinenbau.*
E. T. Z.—*Elektrotechnische Zeitschrift.*
J. f. G.—*Journal für Gasbeleuchtung.*
L. u. L.—*Licht und Lampe.*
Z. f. B.—*Zeitschrift für Beleuchtungswesen.*

EFFICIENCY.

The wonderful reflecting surface of "Superlux" Glassware makes it the most efficient glass reflector extant. It is a new and exclusive discovery.

List No. G 1727 post free on request.

CLEANLINESS

No glass reflector on the market collects so little dust. This is due to its being perfectly smooth and round and having no grooves either large or small upon its surface.

"Superlux"
GIVES PERFECT LIGHT

IN EVERY SINGLE ATTRIBUTE—the very best.

VENTILATION.

The suspension of the glass reflectors is by ordinary gallery, which is the only way efficient ventilation can be provided for. Enhanced appearance and facility in fixing are amongst the many other advantages of this method.

THE
General Electric Co.,
LIMITED,
Head Office—
67, QUEEN VICTORIA ST.,
LONDON, E.C.

TRADE TOPICS.

[At the request of many of our readers we have extended the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

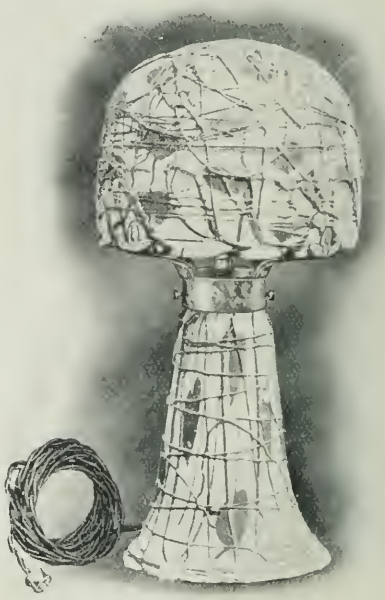
B.T.H. "FOSTORIA" TABLE LAMPS.

The "Fostoria" Table Lamp shown in the illustration represents a distinct departure from the traditional table standard design.

B.T.H. "Fostoria" lamps are made of glass—either white veluria or tinted iris—moulded into quaint shapes and etched with charming designs. Both the pedestal and the dome or reflector of the "Fostoria" table standard are made of glass. Beautiful effects are obtained by using, in the case of three out of the four available types, a small lamp in the pedestal as well as under the dome.

The glass of which these table standards is made has excellent diffusive qualities, so that when both Mazda lamps are alight, the whole of the standard radiates a soft, uniform brilliance. Of course, the greater part of the light from the lamps is reflected downwards on to the table.

Readers should visit the B.T.H. Co.'s showroom, MAZDA HOUSE, 77, Upper Thames Street, E.C., and inspect these table standards.



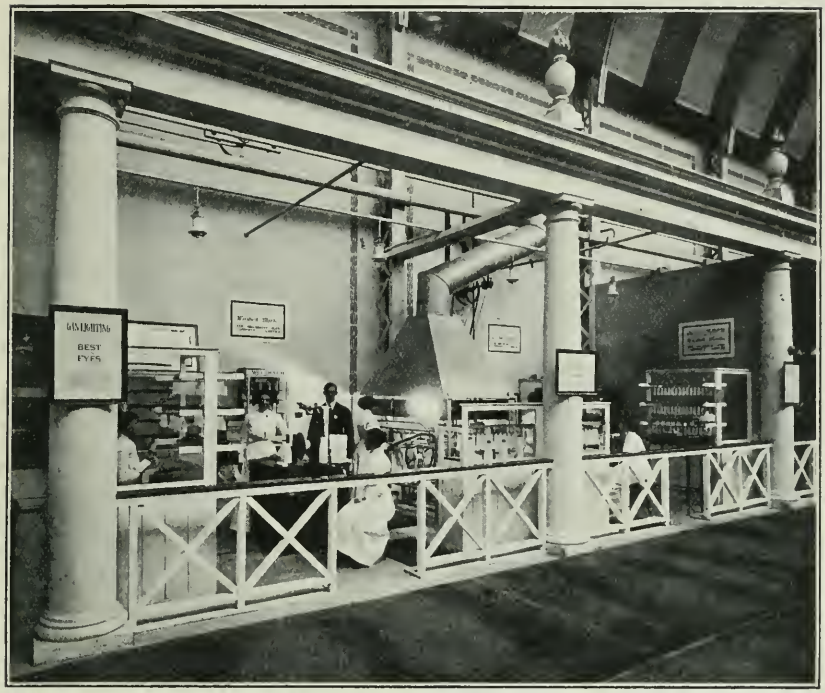
"VERITAS" PUBLIC LIGHTING REQUISITES.

In a recent number (September, p. 482) we described the UKAY lamp, produced by **Messrs. Falk, Stadelmann & Co.** (83, 85, and 87, Farringdon Road, London, E.C.). The model then shown was essentially a suspension lamp, but we observe from the catalogue now received that it is now also produced in the form of a pillar lamp for street lighting. The chief characteristic of the lamp is the solidity and accessibility of the parts, and the body of the lamp can be readily removed from the supporting iron structure. The construction enables this to be done without interrupting the gas supply—a very desirable quality in a lamp intended for public lighting.

PERSONAL.

Mr. W. H. Mulhall, who was formerly associated with Messrs. Siemens Bros. Dynamo Works, Limited, Dalston Works, as traction lamp expert, has been transferred to Glasgow Branch to handle their general electrical business in that district.

WELSBACH MANTLE-MAKING AT THE GAS EXHIBITION.



This illustration shows the exhibit of mantle-making in the Industrial Hall, at the National Gas Exhibition. A feature was the demonstration of the knitting of the stockings, and the burning off of Welsbach mantles, as shown by the **Welsbach Light Company** (344-354, Gray's Inn Road, London).

"THE LAST WORD IN STREET LIGHTING."

The Wardle Engineering Co., Ltd. (196, Deansgate, Manchester), issue a pamphlet under the above title, describing their latest suspension devices for street lamps. These methods are illustrated by a series of photographs of centrally suspended units in London and the provinces, and a typical case is described (with costs) at Barrow-in-Furness. The maximum illumination (0.35 ft.-candle) and the minimum (0·03 ft.-candle), giving a ratio of maximum/minimum of 12 : 1 are stated for the above installation. In view of Mr. Trotter's recent paper on street lighting, it is interesting to see that manufacturers are becoming alive to the importance of giving the illumination values in the streets.

UNION EYE-COMFORT SYSTEM.

The Union Electric Co. (Park Street, Southwark), send us a booklet illustrating the use of the indirect and semi-indirect are "Eye-Comfort" system for a wide variety of industrial uses—clothing factories, jewellers, lithographers, printing works, &c.

An impressive feature is the list of a considerable number of establishments in which this method is installed, illustrated by an excellent series of photographs taken under the artificial light. Several of these are in the nature of "snapshots," figures of people at work being shown; it is an undeniable feat to take photographs of this kind by artificial light.

PERSONAL.

We understand that Mr. Justus Eck, Manager and Chief Engineer of the Union Electric Co., left London last month on a tour in the United States. Mr. Eck carries with him the good wishes of many friends in this country.

LIGHTING A FURNITURE SHOWROOM.

Two views of the Furniture Department of Messrs. J. Hide & Co. (Market Place, Kingston), lighted by Holophane bowl reflectors.

(*Photo. taken entirely by artificial light.*)

In a furniture showroom good diffusion is absolutely necessary. The above photograph supplied by **Holophane, Ltd.** (12, Carteret Street, Queen Anne's Gate, London, S.W.), shows how the light should be reflected from many different directions so as to get into the recesses of cabinets, to illuminate the floor underneath desks and tables, &c. In addition, there will probably be in the room such objects as china, lamp shades, &c., having intricate patterns on them which can only be seen properly in a good light. Few things are more annoying to a customer than to have to examine such objects in a poorly lighted room.

COOPER HEWITT LAMPS.

The **Westinghouse Cooper Hewitt Co., Ltd.** (80, York Road, King's Cross, London), send us an account of the use of the mercury lamps for lighting hosiery works, where intricate machinery and a large number of revolving bobbins are in use, and the good diffusion from a line source is said to be a distinct advantage. For the same reason this type of lamp is very conveniently used for blue printing outfits, and its initial cost is claimed to be soon repaid where any considerable quantity of prints are required.

Another communication from this firm relates to a case in which an engine driver was apparently deceived by a distant mercury lamp on a Cinema building, mistaking it for a green signal. It is pointed out that such confusion is readily avoided by using an appropriate reflector —another instance of the importance of shading in illuminating engineering!

OSRAM LAMPS.

The metallic filament lamp has opened quite a new era in theatre lighting. We are informed that a number of Osram drawn-wire lamps have been recently introduced to light the vestibule of the London Opera House, and they have also been installed in many other London and provincial theatres. It is also stated that most of the large railways and steamship companies are using a considerable number of these lamps, the total output amounting to several millions yearly.

INDEX, November, 1913.

PAGE

Correspondence (P. J. Waldram, An Engineering Correspondent) 578
Daylight and Night—Which is Which? 576
Editorial 527
Ideal Home Exhibition, The 571
Illuminating Engineering Society (U.S.A.), Annual Convention 531
Illuminating Engineering, Short Notes on 579
Indirect and Semi-indirect Lighting in a Small Home 573
Photographic Dark Room, Lighting of 578
National Gas Exhibition, Account of Proceedings at Conferences, &c. 539
Description of Exhibits 545
Papers read (Prof. S. P. Thompson—Septimus Warwick and Austen Hall—L. Gaster—Dr. S. Rideal—Dr. T. Meredith Young—Franklin Thorp 551
Review of Technical Press 583
Trade Notes 586

"ENGINEERING ABSTRACTS"

(Journal of the International Institute of Technical Bibliography)

is an illustrated International Review of the World's Engineering Progress. It is published monthly in seven sections, dealing with the various branches of engineering, and containing indexes and abstracts of all important books, articles, &c., published everywhere in the world.

For Illuminating Engineering see Section II. (Electric Lighting, &c.) and Section VII. (Lighting in General).

Full particulars, Specimen Copies, &c., from the Secretary,

International Institute of Technical Bibliography,

57/58, CHANCERY LANE, LONDON, W.C.

THE

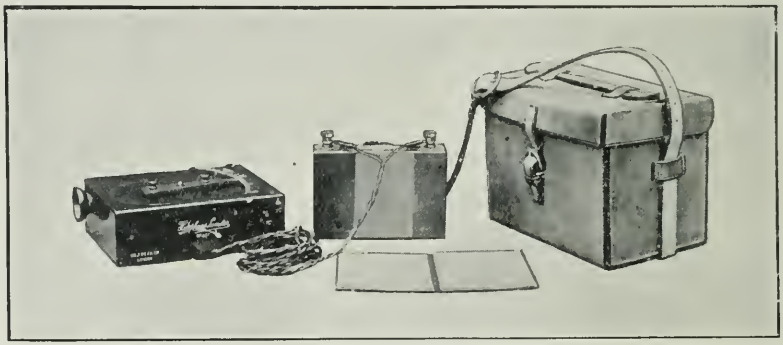
Holophane Lumeter.

THE simple, portable, and accurate apparatus for measuring illumination, surface-brightness, or reflecting power.

Can be carried from place to place with the ease of a small hand camera.

Dimensions only $5\frac{3}{4}$ in. × $4\frac{1}{2}$ in. × $1\frac{3}{4}$ in.; case and accumulators supplied.

Measurements from 0·01 to 2000 foot-candles can be made.



Showing general appearance of new model of Holophane Lumeter.
(Dimensions : $5\frac{3}{4}$ in. × $4\frac{1}{2}$ in. × $1\frac{3}{4}$ in.)

The Holophane Lumeter is of value not only to lighting engineers, but to architects, medical officers, factory inspectors, photographers, and many others.

Among the users of this instrument may be mentioned :—

The House of Commons, The Home Office (Factory Dept.), The London County Council, General Post Office, Great Western Railway, L. & S.W. Railway, Underground Railways, The Gas Light & Coke Co., St. James and Pall Mall Electric Supply Co., The Union Electric Co., The British Thomson-Houston Co., &c., &c.

For all particulars apply to

HOLOPHANE, LTD.,

12, Carteret St., Queen Anne's Gate, S.W.

The ILLUMINATING ENGINEER
ELECTRICITY · ACETYLENE · OIL · GAS
Edited by LEON · GASTER

THE JOURNAL OF SCIENTIFIC
ILLUMINATION.
OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London, 1909.)
ILLUMINATING ENGINEERING PUBLISHING COMPANY, LTD.,
32, VICTORIA STREET, LONDON, S.W.
Tel. No. 5215 Victoria.

EDITORIAL.

The Illuminating Engineering Society: Its National and International Aspects.

At the first meeting of the session on November 18th the customary report of progress during the vacation was presented. Events now march so rapidly that there is always plenty to report after the vacation, and it is a good plan to summarise at intervals the progress that has been made. It will be noticed, too, that in this number we are reproducing part of the special Report of Progress presented at the recent Convention of the American Illuminating Engineering Society, a new feature undertaken by our friends in the United States which will doubtless be much appreciated by readers in this country.

There is one point mentioned at the meeting of our Society on November 18th to which we should like to draw special attention, namely, the proposal to extend the sphere of operations of the Society in the provinces.

From the very commencement the Society has always aimed at international co-operation. Time has already shown the wisdom of this step.

But, as was remarked by Mr. Shadbolt at one of the Conferences at the National Gas Exhibition, there is every reason for the Society, besides being international, to be also *national,* in its scope. There are already a considerable number of members of the Society in the provinces who can only occasionally get to the meetings in London and who would gladly assist to raise local interest in the movement.

It is, therefore, proposed to appoint representatives of the Society in the various districts with a view to securing an increase in local membership. When a sufficient number of members has been obtained it is hoped to hold during the year one meeting at each centre, at which topics of local interest would be discussed. This would be an important step forward and no doubt there will be other developments in the future.

Naturally, a considerable amount of preparatory work has to be done before taking a step of this kind and the first matter that requires attention is to secure an increased provincial membership. We therefore, hope that all members residing out of London will take this matter up and do their best to induce their friends to join.

While inaugurating this new policy, the Council does not mean it to be inferred that the Society will in any way abate its international activities. On the contrary there is now every reason to aim at more complete international co-operation. It has often struck us, for example, that many of the excellent papers presented in the United States might be simultaneously discussed in this country. Now that there is also a Society in Germany at work it would often be desirable for important papers to come before the notice of members in all three countries. In our last number we drew attention to the variety of topics dealt with at the Convention of the American Illuminating Engineering Society, and we now notice that at the meeting of the German Society on November 8th, three interesting papers, " Alterations and Injuries of the Eye Caused by Light " (by Dr. F. Schanz), " Testing the Colour of Illuminants " (by Dr. L. Bloch), and the " Laws of Radiation from Glow Lamp Filaments and their Temperature Determination " (by Prof. Lummer), were read. Such topics as these would naturally interest illuminating engineers in all countries, and we think that a plan might be devised of bringing them before a wider audience.

We are glad to note that during the vacation there has been a substantial increase in the membership of the Society and, what is still more gratifying, support has been secured from a number of distinguished authorities in various parts of the world. It will also be observed that reference is made to the formation of the National Commission on Illumination, from whose labours much good will doubtless follow in the future.

Sir William Preece.

We regret to record the death of Sir William Preece, one of the most distinguished Vice-Presidents of the Society.

On page 600, Mr. Trotter has contributed a most interesting and felicitous account of his work and personality.

A few words may perhaps be added by one who, although he only met Sir William Preece when the latter had already reached the zenith of his career, had several opportunities of appreciating his lovable character and sterling qualities.

The illuminating engineering movement owes a great debt to Sir William Preece. His early pioneering work paved the way for much that is being done to-day, and in later life he was intimately interested in the movement. I recall that he was in the chair when I read a paper before the Royal Society of Arts in 1906 ; it was on this occasion that the need for the illuminating engineer was first mentioned. Afterwards, when I was trying to gain support for the project of forming an illuminating engineering society, he was among those who encouraged me to persevere ; and the readiness with which he had listened to what I had to say was typical of the accessibility to which Mr. Trotter refers. And when eventually the paper on the need for the illuminating engineer was presented before the Association of Engineers in Charge in the autumn of 1907, Sir William Preece consented to preside, and was only prevented at the very last minute from doing so.

The Society took an early opportunity of expressing its great indebtedness to Sir William by nominating him one of the first Honorary Members, an intimation which he acknowledged with characteristic grace and courtesy. By the death of Sir William Preece the illuminating engineering movement has lost a valued friend and the Society one of its most distinguished supporters.

Some Problems in Daylight Illumination.

It was announced at the last meeting of the Society that a paper on the above subject is to be read by Mr. P. J. Waldram on December 16th. The paper, while in a great measure the result of Mr. Waldram's personal efforts, will also contain references to matters coming within the scope of the Sub-Committee of the Society on Daylight Illumination in Schools, and we understand that a special feature will be a compilation of literature bearing on this subject. Meantime we publish on page 608 a list of queries on daylight illumination which are being widely circulated. We hope that members of the Society throughout the world who are interested in this subject will give us the benefit of their experience.

If a room is lighted by artificial means it is always possible to rearrange the lighting at a comparatively small cost if the results are unsatisfactory. But when a building has once been erected it is rarely possible to make any substantial change in the arrangements for admitting daylight. It will be understood, therefore, how vital it is for the planning of schools, libraries, and other public buildings to be carefully carried out in the first instance, and we hope that the discussion of Mr. Waldram's paper will be instrumental in establishing some of the principles on which this should be carried out.

Shadows by Natural and Artificial Light.

On pages 619-631 we reproduce the paper on this subject read by Mr. J. S. Dow and Mr. V. H. Mackinney at the last meeting of the Illuminating Engineering Society. The paper is accompanied by a variety of illustrations, and anyone who has carried out photography of this kind will appreciate the amount of work the preparation of such a paper entails. It may well be said that photography is becoming an indispensable art to the illuminating engineer, for the science of illumination is based essentially on an appeal to the eye. A good picture will convey in a few minutes what a long explanation in words might fail to make clear. It is therefore important to understand how the reproduction of artificial lighting conditions may be made as accurate as possible.

Photographs representing shadows should have a special utility, for it is difficult to record these effects in any other way. We are only just beginning to realise what an important part is played by shadows in illuminating engineering. In the factory the utility of a system of lighting must depend to a great extent on the direction from which light strikes the tools and implements.

In the same way shadow plays an important role in the æsthetic side of lighting, an interesting feature pointed out by the authors being the curious reversal of daylight shadow that often occurs by artificial light. This is a point on which the views of the architect should be obtained. It is sometimes argued that architecture is an art that has developed in accordance with daylight conditions, and that the finest buildings were designed with a view to their being seen in the daytime and not by night. But it may surely be suggested that in our modern times, when artificial light is obtainable so readily in large quantities, its value for decorative effects should be considered, and it is possible that its judicious use for this purpose would open out an entirely new vista in decorative art.

LEON GASTER.

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of "The Illuminating Engineer."

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

A YEAR'S PROGRESS IN ILLUMINATING ENGINEERING.

(A Report presented at the Seventh Annual Convention of the American Illuminating Engineering Society, Pittsburgh, Pa. (U.S.A.), September 22-26th, 1913.)

During the past year the science of illumination has probably made greater progress than at any other similar period of its history. While few radical changes or developments have been made in connection with light sources, improvements have been made in mechanical construction of present systems, resulting in increased efficiency, and illumination has become the subject of study by physicists, oculists, architects, legislative bodies and others as never before.

Incandescent Electric Lamps.

In connection with light sources the development of the tungsten lamp stands out most prominently. This, in high candle-powers, is a serious competitor of the arc lamp both for indoor and outdoor lighting, and has largely superceded the carbon filament lamp, as shown by the following table taken from a recently published article, and giving the relative number of lamps sold.[1]

It is extremely probable that more recent figures will show that the tungsten lamp, aided by greatly reduced price, its high efficiency and the fact that electric companies are beginning to make free renewals of tungsten lamps as they did of the carbon filament, is destined to make the carbon filament lamp a vanishing quantity. In this connection it is interesting to note that the United States Government has issued an order through the office of the supervising architect of the Treasury Department that carbon and metallised carbon-filament lamps are not to be used in any of the Government buildings, and any such lamps in use at the time of the receipt of the order must be removed and 25-watt tungsten lamps substituted.[2]

There has been marked improvement in the life of some of the higher wattage 100-volt types and in compensator and train lighting lamps. In the 60, 100 and 150-watt, 100-volt lamps improvements

Type.	Per cent. 1907.	Per cent. 1908.	Per cent. 1909.	Per cent. 1911.	Per cent. 1911.	Per cent. 1912.
Carbon ..	93·27	84·12	68·98	63·08	52·90	25·47
Gem	5·88	8·58	15·07	14·88	19·00	33·59
Tantalum ..	0·75	1·78	2·12	3·57	2·74	1·00
Tungsten ..	0·10	5·52	13·83	18·47	25·30	39·94
Total ..	100·00	100·00	100·00	100·00	99·94	100·00

[1] *Lighting Journal*, July, 1913.

[2] *Electrical World*, March 15th, 1913.

in life have taken place similar to those made last year in the cases of the 250, 400 and 500-watt lamps. This improvement in quality is on the order of 50 per cent. in life and has made possible substantial improvements in efficiency. The use of chemicals—the so-called "vacuum getter," in the bulbs of these lamps for reducing the blackening of globes has largely brought about these improvements.[3, 4] At present the commercial efficiencies of these types are around 1·17 w.p.c. while the higher wattage types are put out at about 1 w.p.c.[3, 4]

To meet a demand for a 60-watt small base lamp for use in residence lighting and to provide a 40-watt lamp that will in all cases be interchangeable with the 25-watt lamps these two types are now made in smaller bulbs. The 60-watt lamp is now made in the same bulb as was standard for 40-watt lamps and the 40-watt lamp in the bulb which is now standard for 25 watts. This change has been made without impairing the life or efficiency of the lamps.[3]

Improvements in the tungsten wire-drawing process have made it possible to manufacture wire of almost exactly the desired size and so render it possible for manufacturers to make lamps of so nearly the desired voltage and efficiency that the function of photometry in the lamp factory is now principally to guard against errors in manufacture. This improvement has been adopted by most of the manufacturers in this country for all lamps intended for series burning service and has been productive of greatly improved results in all cases.[3]

A 10-watt, 100 to 130-volt lamp and a 5-watt, 50 to 60-volt lamp have been developed. These are important additions to the line of sign lamps in that they furnish a low wattage lamp that does not require the operation of more than two lamps in series upon 100 or 200-volt circuits.

Miniature lamps of the candelabra and decorative types with tungsten filaments have been developed for 110-volt circuits. These have the filaments wound to form a helical coil of small diameter and this helix is then mounted on the supports in the same manner as an ordinary filament. The mandrel around which the filament is formed is so small that the helical construction of the filament can scarcely be recognised with the naked eye. This style of construction renders possible the use of fewer supports and smaller bulbs than ordinary tungsten lamp construction would allow.[3]

During the past year the use of concentrated filament tungsten lamps has enormously increased. At the present time a very large proportion of the automobiles now being sold in this country are equipped with these lamps. Concentrated filament lamps are also being used for stereopticon work, for trolley car headlights and for theatre stage lighting in place of arc lamps and Nernst lamps. With the style of construction now used excellent concentration is obtained; the filament for a 100-watt, 115-volt lamp occupies a space only 7/16 inch (11·113 mm.) in diameter and 7/16 inch long.

A new filament consisting of an alloy of tungsten has also been brought out. It is claimed that this not only possesses the strength and efficiency of drawn tungsten, but that it will withstand crystallisation for a longer period.[5]

An investigation has been made upon the heating of screw thread lamp sockets. This was found to be almost entirely due to the heat dissipated by the lamp or radiator and has little to do with the energy lost in contacts. Bayonet holders are satisfactory up to 250 watts, while screw sockets can transmit energy up to 1,000 watts with satisfaction.[6]

Possibly the most startling development in the tungsten lamp is the announcement of one giving an efficiency of 0·5 watt per candle. A specially shaped tungsten filament is used in a bulb containing an inert gas, as nitrogen, at a pressure of about one atmosphere. The types to be developed first are adapted to high current consumption, say 6 amperes, and over.[7]

A tungsten lamp has recently been brought out which gives a colour very closely resembling that of daylight. It is not, however, an exact equivalent, and

[3] *Electrical Journal*, June, 1913.
[4] *Electrical Journal*, January, 1913.
[5] *Electrical World*, December 7th, 1912.
[6] *Electrician*, June 27th, 1913.
[7] *Electrical World*, July 19th, 1913.

is, therefore, not suited to colour matching. The energy consumption of this lamp is about 1·4 watts per candle, and it has a candle-power of from 70 to 75.[8], [9]

A method of testing for spots in incandescent lamp filaments has been developed in which the body of a filament is made to disappear against a luminous background until the light or dark spot shows by contrast.[10]

Experiments were made to determine the variation in candle-power produced by frosting. The distribution curves were found to be very much the same before and after frosting, and half-frosting resulted in a reduction of from 10 to 20 per cent. in the candle-power. One fact brought out in these experiments was of practical use in permitting a close estimate to be made of the efficiency of a half frosted bulb. It was found that the curves for the distribution of light of each lamp, clear and half frosted, intersected at an angle very close to 66° in each case, and the candle-power at this angle is in each case very nearly 45 per cent. of the horizontal candle-power of the clear lamp. Thus the horizontal candle-power of the clear bulb may be obtained by multiplying that obtained with the half frosted bulb at 66° by 2·22.[11]

A focusing tungsten lamp with a spherical bulb silvered near the socket has been introduced within the past year. This lamp, which is rated at 32 candle-power has an efficiency of 1 watt per candle. In another lamp there is a specially shaped reflector in close proximity to the filament. The leading-in wire enters at the apex of the reflector and leaves at its circumference.[12]

A system has been developed in which 14-volt lamps are used with a special transformer for each lamp or for each group of lamps. Each transformer is connected in parallel to the line, and when it is disconnected the primary circuit is broken so that there are no no-load losses. These lamps are cheaper than the standard 110-volt lamps, in addition to which advantage are the long life and the possibility of using low candle-power. The lamps are thought to be especially suitable for agricultural districts.[13]

In order to avoid the excessive glare inherent in filament lamps, a patent has been taken out according to which the outer surface of the lamp bulb is made in a series of fine substantially parallel grooves constituting a system of prisms. The grooves may be arranged in various ways.[14]

Electric Arc Lamps.

The open and enclosed series and multiple arc lamps are fast disappearing, their places being taken by the magnetite and the flame arc lamps. There seems to be during the past year, as far as arc lamps are concerned, a strong tendency towards the use of larger units and the cutting down of intrinsic brilliancy of the arc even at a sacrifice of efficiency.

The flame arc lamp is of special value in lighting large areas, and is particularly adapted to smoky and dusty places, such as foundries, blacksmith shops, and railroad train sheds. In fact one of the largest railroads in the country spent months in trying out various systems in lighting for the train shed of one of their large stations, and, after experimenting with various systems of lighting finally decided to use the flame arc lamp exclusively, adopting it also for the yard.

This lamp has been improved so that the fumes thrown off by the arc are condensed and so are prevented from forming a deposit on the globe and from escaping into the air. The lamp is also economical as far as maintenance is concerned, as one set of carbons will burn from 100 to 120 hours without attention.

A rather novel device is an arrangement for converting any enclosed arc lamp, alternating or direct current, series or multiple, and regardless of voltage, into a flame arc lamp.[15] Many minor improvements have been made in construction of the arc lamp such as making the clutch work on the electrode indirectly, thereby keeping it independent of the size of the electrode, improving the feeding arrangement, &c. The lamps are now made to give any desired range of colour and to

[8] *Zeit. für Beleucht.*, April 30th, 1913.
[9] *Elek. Anzeig.*, April 24th, 1913.
[10] *Electrical World*, May 3rd, 1913.
[11] *Electrician*, April 25th, 1913.
[12] *Elek. Anzeig.*, April 24th, 1913.
[13] *Electrical World*, December 28th, 1912.
[14] *Electrical World*, September 14th, 1912.
[15] *Electrical World*, March 1st, 1913.

work under any ordinary condition even, as in one lamp recently introduced, on a 25 cycle circuit. and have reached an efficiency of 0·25 watt or better per candle with possibilities of further improvement.

One of the most interesting applications of the long-hour series alternating current flame carbon arc lamp is to low frequency circuits of 25 cycles. With the unimpregnated carbon lamp, there is a flicker at each reversal of polarity which, at this frequency, is very marked. In the flame arc lamp, the light is obtained from the arc screen and is, therefore, independent of polarity.[16]

A discussion was reported about the end of last year in which were reviewed the results produced upon the stability of the electric arc by wind currents, magnetic fields, movements and presence of solid obstruction, &c.[17] In an investigation made in regard to the evaporation temperature of the arc lamp it was found that the temperature is independent of the current, but varies with atmospheric pressure, proving that the atmosphere of the crater is at the boiling temperature of carbon. A peculiar phenomenon noticed was that the positive crater seems to begin to boil at pressures below atmospheric.[18]

Vacuum Tube Lamps.

One of the more recent developments of the mercury vapour lamp is a combination with the tungsten, an apparent white light being thereby produced. The unit is very compact and is furnished with a novel starting device. The consumption of this lamp is claimed to be 0·73 watt per mean hemispherical candle-power.[19] Another recent form of the mercury vapour lamp is one with a specially designed quartz tube and designed particularly for street lighting. This lamp is started by means of a heated spiral which vaporizes a small portion of the mercury; this is automatically cut out of circuit when the lamp is in operation and renders tipping unnecessary. The lamp is recommended for the varying voltages met with on traction circuits and is said to consume about 0·4 watt per candle.[20, 21]

Another development has been the use of tungsten instead of platinum wires for sealing in of the electrode wires and the employment as a sealing material of a special high temperature glass, having nearly the same coefficient of expansion as the tungsten. Graded glass is inserted between the sealing glass and the quartz chamber walls in order to effect a suitably graded transition from the quartz to the sealing material.[22]

A new method has been devised, applicable to any lamp depending upon a vacuum, of sealing the conductors through the glass, and by which perfect seals may be obtained between easily oxidizable metals and glass of low fusing point. After inserting the conductor through the aperture in the glass, the latter is strongly heated by means of a blow pipe flame until perfect cohesion has been obtained between the glass and the metal. The seal is then taken out of the flame, and when it reaches a dull red, the leading-in wire and the glass surrounding it are cooled by several immersions in a special bath, say of sperm or other oil, wax or fat.[23]

The value of the ultra-violet rays of the quartz tube mercury vapour lamp is becoming recognised. The lamp is now used for sterilising and the destruction of bacteria. This effect, however, decreases in time. due partly to the formation of an obscuring deposit.[24]

Announcement has also been made of a vapour lamp giving a white light. In this the tube is filled with the vapour of cadmium with from 3 to 10 per cent. of mercury. At its most economical point the specific consumption is 0·16 watt per candle.[25]

A new source of light for photo-electric work and said to have an effect 250 times as great as the mercury lamp has been introduced. This is a vacuum discharge tube containing hydrogen at low pressure.[26]

Various investigations have been made upon the characteristics of neon lamps.

---

[16] *Electrical World*, July 26th, 1913.
[17] *Electrical Journal*, December, 1912.
[18] *Jnl. für Gasbel.*, July 12th, 1913.
[19] *Illuminating Engineer* (London), October, 1912.
[20] *Electrotech. Zeitschr.*, March 20th, 1913.
[21] *Elek. Anz.*, February 13th, 1913.
[22] *Electrical World*, May 10th, 1913.
[23] *Electrician*, July 4th, 1913.
[24] Soc. Int. Elect. *Bull.* 2, Sec. 3, June, 1913.
[25] *Electrotech. Zeitschr.*, September 5th, 1912.
[26] *Physical Review*, April, 1913.

It was found that when the tube was placed in an alternating current 4,000-volt circuit with a transformer and condenser, 0·72 amperes usefully traversed the tube. Introduction into the circuit of more neon tubes, instead of decreasing the current, apparently increased it up to four tubes, after which the current diminished. The phenomenon was not explained, but it was evidently not due to resonance.[27]

Disappearance of various gases by passing a discharge for some time through vacuum tubes was the subject of another investigation and was found to be due to definite chemical action rather than to physical absorption.[28]

Investigation made also of the cause of the short life of neon tube lamps showed that it was due to absorption of neon by the electrodes, and that if the current density at the electrodes was small, the life of the lamps would be greatly increased. By employing very large electrodes, therefore, tubes showed no deterioration in 2,000 hours' use.[29, 30]

(*To be continued.*)

[27] *Le Genie Civil*, December 14th, 1912.

[28] *Electrician*, November 15th, 1912.
[29] *Electrician*, May 30th, 1913.
[30] *Comptes. rendus*, April 28th, 1913.

LIGHT, ANCIENT AND MODERN.

A POPULAR lecture on this subject was given by Mr. F. H. Taylor at the Willesden Polytechnic on Wednesday, October 1st.

The lecturer sketched the development of light in very early times, traced the conditions in Old London when every householder was compelled to hang up a light outside his door, and described some of the early experiences of the Gas Light and Coke Co. a century ago.

Subsequently Mr. Taylor turned to modern times, making special reference to the great progress in modern illuminants.

The following is a quotation from the *Standard*, summarising his final remarks :—

A GREAT DEBT.

"Even more remarkable than the development in new types of lamps," said Mr. Taylor in conclusion, "is the development which has taken place in the proper application of light. The public in general owe much to the work of the youngest scientific society in London, *i.e.*, the Illuminating Engineering Society. Founded in 1909, it has in that short time not only collected and published an immense amount of knowledge on the science of illuminating, but has done great good by pointing out to people the awful errors in bad lighting and the consequences of these errors. Such work would hardly have been possible but for the fact that we include in that society not only representative men in every branch of lighting—in electric lighting, gas lighting, oil, and acetylene, but also medical men and oculists."

ILLUMINATION AND MODERN METHODS OF LIGHTING.

AT a meeting of the Association of Engineers in Charge (London) on Saturday, November 15th, a lecture on the above subject was given by Mr. H. C. Wheat, who showed an ingenious little cupboard in which demonstrations of the utility of various kinds of reflectors were given. The hall was lighted by a variety of indirect and semi-indirect units, and a selection of reflectors made of glass and metal was exhibited.

It is interesting to note that it was in the hall of the Association of Engineers in Charge, which is thus demonstrating its continued interest in illumination, that the historic meeting took place in 1907, when Mr. Gaster read his paper on the need for the Illuminating Engineer. It was at this meeting that the forthcoming publication of THE ILLUMINATING ENGINEER was first announced.

Sir William Henry Preece.

Born Feb. 15th, 1834—Died Nov. 6th, 1913.

On November 6th there passed away, in his eightieth year, one of the pioneers of telegraph engineering, the friend of Professor D. E. Hughes, Latimer Clark and the old guard of electrical engineers.

Other journals have described his parentage and education, his early connection with railway signalling, the development of telegraphy under his administration at the Post Office, and the many scientific societies of which he was a member. The mere titles of the papers which he read before them would fill two of these columns, and ten or more of them relate to lighting and photometry. It is significant of his huge activity that the notices of his death in other journals have said little if anything of his work on these subjects, and it is fitting that this page should deal with little else.

Sir William Preece's good nature made him an easily approachable man, notwithstanding the important position which he held at the Post Office. In 1883 he was advising the Streets Committee of the Commissioners of Sewers of the City of London on the experimental lighting of the streets. I went to see him with samples of my dioptric shades. A messenger took him my card, there was no watchdog secretary or assistant to keep off an unknown young man with an invention and with no introduction, he received me with kindness and promised to test my shades at the first opportunity. This led to my seeing a good deal of his street-lighting experiments and of his laboratory work. In this he was assisted in details by H. R. Kempe and I. Probert, but I believe that he was the first to recognise and to make practical measurements of illumination as distinguished from candle-power, and he showed how in street lighting such measurements added up the illumination received from several lamps. The association which I was privileged to have with him in the construction of three or four different photometers for the direct measurement of illumination on a horizontal plane enables me to judge of his intimate knowledge of the scientific side of such work, his desire to achieve the conflicting ends of accuracy and of simplicity, and his zeal for practical

results. I remember his delight in finding that his photometer demonstrated the falling off of the lighting at the west end of Holborn Viaduct, owing to the resistance of the mains fed from Edison's "Jumbo."

One other branch of his work—his labours in connection with units and standards—should not be forgotten. Besides being the originator of the illumination photometer Sir Wm. Preece was responsible for naming the unit of illumination. At the Paris Electrical Congress of 1889 he proposed for the carcel-metre the term "lux."

There was much talk in those days of the subdivision of electric light. He recognised the limitations of the arc, and after satisfying himself of the practicability of the project, he carried out the lighting of a street in Wimbledon in May, 1884, with Swan lamps in series-parallel supplied with current from a Hochhausen nine-ampere arc lighter. Several different kinds of his street photometers were used. A handcart with six huge bichromate cells and a Cardew differential galvanometer with two resistance boxes were needed, and he made measurements of the illumination at every ten feet and plotted the illumination curves and by them compared several different kinds of reflectors. Thus he would spend his evenings after his responsible official work at the Post Office, but in the early morning he would put on a jacket and sit up in bed and patiently work out not only the tedious calculations of photometric quantities with cosine tables, but the electrical measurements which the crude photometers of those days necessitated; and it was thus that he wrote his innumerable lectures and papers.

Lucid as a writer, facile as a speaker, and more original as a thinker than some of us imagine, his useful work outside his official duties did not consist so much in contributions to engineering or to science as in his influence on the public. He was better at the Society of Arts or at the British Association than at the Institutions of Civil or Electrical Engineers. At those latter meetings he seemed to do himself injustice at times, but perhaps he knew his audience better than they knew themselves. He threw himself enthusiastically into such enterprises as the really useful exhibitions of the 'eighties, and in working up a lecture he would secure the best information, and afterwards astonish those whom he had consulted by a far better presentation of their facts than they could have given. Thus in his vigorous and felicitous manner he brought electrical engineering and the science of the day down to the popular level. This is a thankless task. It is not valued by deep thinkers whom the public cannot understand, nor can it be judged by those engaged on great undertakings which the public can only vaguely appreciate.

I saw my old friend at his house near Carnarvon about three weeks before his death, sitting in his library, the shelves full of notes and papers, the tables covered with books on Egyptology, and the floor strewn with the weekly electrical and engineering journals. He could speak only in a whisper, but suffered no pain. Amongst other things he spoke of the advances of street lighting and the photometry of illumination, and regretted that he had been unable to attend the meetings of the Illuminating Engineering Society.

A. P. Trotter.

NATIONAL GAS EXHIBITION.

Some Proceedings at the Conference of Manufacturers taking place on Wednesday, October 29th, 1913.

The proceedings at this Conference, which took place at the very end of last month, were necessarily omitted from our last number. We now take the opportunity of giving a brief summary of the papers presented.

The Conference was opened by Lord Weardale, who remarked that the subject for discussion was one of immense industrial importance. It was now recognised that, whatever had been the case in the past, the gas companies, having been granted a monopoly by Parliament, were under the obligation of giving the best possible service to the public. The plan adopted of organising this series of Conferences at the Exhibition was surely an illustration of the desire of modern companies to do all in their power to fulfil these obligations.

The Industrial Uses of Coal Gas.

The paper by Prof. W. A. Bone on this subject dealt mainly with the use of gas for heating purposes. Prof. Bone described in detail the applications of gas in the smelting of metals and in such processes as the melting of aluminium, bronze and alloys in crucible furnaces, &c. Some particulars were given of the industrial consumption of gas in works at Birmingham, Sheffield and Glasgow in connection with the hardening, tempering and annealing of special steels. In this work the necessity for accurate temperature control has led to gas fires being extensively used. In connection with the melting of type used in the printing trade (it was stated that one of the leading London daily papers requires no less than 20 tons of molten metal during sixteen out of the 24 hours) gas heating is also convenient.

In the concluding section of his paper Prof. Bone referred to the distribution of gas at high pressure. He stated that the cost of distribution by this method works out to less than one-third of that of laying a low-pressure main of similar capacity.

Mr. H. M. Thornton proposed a vote of thanks to Prof. Bone and dwelt upon the importance of specialisation. Manufacturers were fully alive to this and in the case of his own firm they had at least six men who were constantly travelling in different parts of the country giving advice on their specialities.

Mr. G. Shaw Scott seconded the vote of thanks and Mr. F. W. Goodenough referred to other uses of gas such as the heating of incubators and crematoriums.

Prof. Bone, in replying, remarked that he had only referred incidentally to surface-combustion, but he hoped to give a lecture on this subject at the Royal Institution at the end of February next.

The Economic Value of Adequate Illumination.

Mr. Leon Gaster recalled that in a communication to the Royal Society of Arts on February 7th of the present year he had pointed out that good illumination of the factory is needed (*a*) as a hygienic necessity; (*b*) as a means of preventing accidents; and (*c*) on purely economic grounds. He quoted at length from the evidence on these points mentioning the valuable germicidal action of sunlight; this was fully recognised in the legislation of Holland, where the employment of women and children was forbidden in underground premises lighted only by artificial means. Reference was made to the legislation of other countries, such as India and New Zealand, when specific reference to the need for good illumination was made. Instances were given of accidents caused by insufficient artificial light. It was also pointed out that in a badly lighted room machinery is rarely properly cleaned and that this frequently paves the way for a breakdown.

Mr. Gaster next alluded to the statistics of the Fidelity and Casualty Co. of New York which showed that the greatest number of accidents occurred in the winter months when much work was done by artificial light. Mr. Franklin Thorp in his paper at the Conference on October 17th had given some similar statistics furnished by the Master Cotton Spinners' Association which led to substantially the same conclusion. Mr. Franklin Thorp also mentioned cases of men leaving one works and applying at another simply because of the better lighting. It was common experience that all the difficulty of all operations involving attention to intricate machinery, special adjustment of parts, fine observation of light and shade, &c., was enormously increased when the illumination was poor. A special case might be made out for extra good illumination in the case of dark materials; a person sewing stuff of this kind needed a much stronger light than one who was working on white linen, &c.—simply because so little light is reflected to the eye.

Mr. Gaster added that the exports of manufactured goods from Great Britain to various countries amounted to hundreds of millions of pounds. The percentage of spoiled material might be estimated at several million pounds, and it was highly probable that a very considerable portion of this sum might be saved by improved illumination. In a recent paper presented at the recent convention of the American Illuminating Engineering Society it was stated that in most large works the cost of a man's labour per day was 3·5 dollars (14s. 6d. a day), while the cost of light for each man was only 0·0206 dollars (1d.) per day. Similar figures had been quoted by Mr. Franklin Thorp and also Mr. Clewell in his book on Factory Lighting. The essential point was that the amount spent on the lighting was in general but a small fraction of the wages bill and the expenses involved in improving the illumination would surely be more than counterbalanced by the improvement in output and quality of work.

The next section of the paper was devoted mainly to a series of suggestions as to points to be observed in factory lighting, such as absence of glare, good diffusion of light and avoidance of flicker. As regards intensity it appeared that for general illumination a value between $\frac{1}{4}$ and $\frac{1}{2}$ a foot-candle would answer; for more detailed operations special local illumination would be needed, the value depending on the character of the work. Another important point was the direction of the light. Inconvenient shadows from cutting tools, circular saws, &c., might easily lead to spoiled work and even to a serious accident. Mr. Gaster also commented on the fact that whereas windows through which natural light is admitted are usually kept fairly clean, people are apt to neglect the globes and chimneys through which the artificial light comes. Mr. C. E. Clewell found that the collections of dust on fittings during three weeks might lead to a loss of light of as much as 40 per cent. The cost of keeping a unit clean during this period should not exceed $2\frac{1}{2}$ cents. (1d.), while the money value of the loss of light during the same period would be 27 cents. (approximately 1s. $1\frac{1}{2}$d.). Mr. Gaster also emphasised the fact that the lighting engineer should be familiar with the processes going on in the factory to be lighted; only thus could he understand exactly where the light should be placed, the direction the light should come from, and what strength of illumination was needed.

In conclusion he suggested several methods of illustrating the benefits of improved lighting, mentioning particularly a method, suggested by Mr. Thurston J. Kent, of timing the operations first with the old conditions of illumination and then with the new, and thus showing the greater speed resulting from better lighting conditions.

The Illuminating Engineering Society were collecting information on such subjects. He hoped that manufacturers and engineers would interest themselves in obtaining records of this kind.

A vote of thanks to the author was moved by Mr. A. J. Whyte, who complimented Mr. Gaster on the good work he had done for many years in connection with the Illuminating Engineering Society. Mr. Whyte also referred to the change in methods of factory lighting during recent years. Formerly things were done on a more or less rule of thumb method, but it was

now becoming customary to estimate illumination on a foot-candle basis. If science could be allied to common-sense in this matter a much better result might be obtained.

The vote was seconded by Mr. J. W. Glover, who said that his experience in factories, dating back for half a century, had convinced him of the value of good lighting for securing the health of workers and procuring the quality and production of work. He also entirely agreed as to the desirability of properly arranging and shading the lights and of having a maintenance staff where the installation was large enough.

Subsequently Mr. Goodenough moved a vote of thanks to Lord Weardale, who was unable to remain longer owing to another engagement.

Matching of Colours by Artificial Light.

A paper on the above subject was then read by Mr. T. Thorne Baker, who stated that many industries had been hampered for years by the difficulty of colour matching by artificial light. It must be pointed out, however, that daylight conditions is a somewhat variable quality.

In comparing daylight with artificial light several methods were possible. One might obtain photographs of the spectra of the illuminants to be compared side by side. But probably the best method was to use a spectro-photometer, an instrument, that is, in which the two spectra can be reproduced side by side and the brightness of each colour compared in turn. If, in these circumstances, we find that the brightness of the spectra can be made to agree from end to end we may be tolerably certain that, as far as colour values are concerned, the two illuminants resemble each other exactly.

Most artificial illuminants differ from daylight in having an excess of red in their spectrum and a deficiency of blue. Mr. Baker presented a diagram in this connection showing how by treating an incandescent light by a suitable screen one could subtract from it the surplus radiation and convert it into an exact equivalent to daylight. He had produced in the laboratory a filter capable of producing this change. It consisted of a solution in which were dissolved various aniline dyes. Besides using a liquid cell of this kind to secure the necessary absorption, one could employ a gelatine dry filter. It might be remarked that the incandescent mantle lent itself particularly well to filtration in order to give artificial daylight, and a form of lamp suitable for use in testing or colour matching rooms could be made at quite a low cost. Mr. Baker described a lamp of this kind, and remarked that in order to diffuse the light a ground glass screen should be placed in contact with the light filter. Another method was to place the lamp fairly high up near the ceiling with an opal or white reflector underneath and to colour the ceiling with the right tint, to act as an absorption filter. By indirect lighting of this kind a close resemblance to daylight could be obtained, but it was not so easy to obtain perfect purity. In cases where light filters are employed the deterioration due to the heating of the light filter must be carefully watched. Spare lamps should be set on one side and used as standards from time to time. It was also necessary to pay careful attention to the upkeep of the gas lamp. The spectrum given by a mantle should remain constant, but when accurate colour matching tests are made the mantles should be renewed at frequent intervals and the same make should always be used.

Subsequently a communication sent by Mr. J. Lovibond to the meeting was read out by Mr. Goodenough. This explained Mr. Lovibond's system of testing colours, on which, the author remarked, there was still a great deal of misunderstanding

Mr. F. W. Goodenough said that the whole question of the colour of illuminants was a most important one to manufacturers. He had just had a conversation with several gentlemen interested in the dyeing industry who said that if the question of matching colours by artificial light could be satisfactorily settled it would be of immense advantage to that industry. He was glad to see that the difficulties, although great, did not appear to be insuperable ; and he hoped that Mr. Baker's further researches would enable us to obtain a convenient and economical form of artificial daylight.

Prof. Vivian B. Lewis pointed out the importance of the composition of the mantle. In early days, before perfectly pure chemicals were available, some of the lights gave blue, green and other tints, according as there was a predominance of certain materials in their composition. But of late years, since it had been possible to obtain pure thoria and ceria, much more constant results had been obtained. It was known that the lighting power of an ordinary low-pressure mantle was a maximum with about one per cent. of ceria. But he had found that by putting in as much as two per cent. of ceria a higher illuminating value could be got when high pressure was used and that the light would last for a much longer period. For example, whereas a high-pressure mantle to-day would only give its maximum power for 700 or 800 hours it might, with an increase in ceria, give its maximum light for as much as 3,000 hours. He felt quite certain that if one were to specify a certain pressure for a burner, with a mantle of a certain definite composition, one would ultimately get a light which would be a sufficiently good imitation of daylight for all practical purposes and would be readily reproducible. If Mr. Thorne Baker would make some experiments on these lines they should lead to very valuable results.

Mr. Leon Gaster remarked that the real difficulty was to agree upon a standard of daylight, which was varying from hour to hour and from day to day. Mantles of different manufacture varied somewhat among themselves, and laboratory tests alone were not a sufficient guide to practical conditions.

Mr. Thorne Baker, in reply, said that his statement that incandescent gas was nearer to daylight than any other light must be taken with some reserve. But he had found that when artificial daylight was required at short notice, and it was necessary to prepare filters on the spot, incandescent gas was the most easy illuminant to work with.

Lighting, Heating and Ventilation of Factories and Workshops.

The first section of this paper, by Prof. Vivian B. Lewes, dealt mainly with heating. Subsequently Prof. Lewes referred to the difficulty of laying down any hard and fast rule for either heating or lighting appliances in factories. The workers in cotton mills require a high degree of illumination; but each trade has its own requirements. In general, no matter what the variety of work carried out, a large workshop requires two entirely distinct methods of lighting —a general illumination to enable the floor space and machinery to be seen perfectly, and local illumination concentrated on the special work each man is carrying out.

The lights for general lighting are preferably arranged high out of the worker's range of vision while the local lamps should be completely shaded from the worker's eyes so that he sees only the illuminated objects with which he is working and not the mantle. Moreover, the general lighting is preferably provided by means of lights equidistant from each other, but the local lights are usually spaced irregularly to fit the special need of each workman. In conclusion, Prof. Lewes remarked :—

"There is not the slightest doubt that bad lighting means accidents, bad work, and strained eyesight. But it is undoubtedly also a fact that the more light we have the more we want; and it is a perfectly debatable point as to whether the greater and greater amount of light which we are accustoming ourselves to use is not having a serious effect upon the eyesight, and whether in days to come we may not have to admit that Nature resents excess in this as in everything else. We should never forget this, nor the fact that proper lighting is much more a question of the correct arrangement of lights than of candle-power."

In the discussion which ensued Mr. Goodenough referred to the last point raised by Prof. Lewes. He (Mr. Goodenough) considered that it is only when light is abused that any detrimental effect on the eyes need be feared. For the intensity of artificial illumination is almost invariably far less than daylight.

Prof. Lewes, in the course of his reply, expressed general agreement with Mr. Goodenough. When he spoke of using

too much light he was thinking rather of cases in which the eyes were not shaded from the direct rays of the lamps. In his youth he had done most of his school work by the light of two candles at the side of his books, yet he did not remember feeling any great discomfort from insufficient light. Nowadays one saw youngsters working by the light of an unshaded mantle giving sixty candles within three feet of the eyes. Could it be expected that the eyes would be kept in a fit condition in these circumstances ?

Again, it did not follow that because they had so much illumination in the daytime they should provide an equal amount of light by night. Nature had allowed a certain number of hours of darkness—possibly in order to rest the eyes. It was questionable whether, if the artificial illumination at night-time were habitually as strong as that experienced in the day, this would not be harmful to the eyes.

A vote of thanks to Prof. Lewes was then passed and the proceedings terminated.

THE INDIRECT LIGHTING OF A MOTOR SHOWROOM.

The two illustrations on the opposite page show one effective method of lighting a modern motor showroom. The premises in question are those of the Studebaker Co. in Great Portland Street, which are illuminated by indirect units, containing Osram lamps.

Fig. 1 shows a view of the interior of the showroom, Fig. 2 a general view taken outside in the street in which the two lower floors of the building belonging to the company are seen brilliantly lighted up. The showroom on the ground floor is 61 ft. 6 in. long, 51 ft. broad and 13 ft. high, thus occupying roughly 3,000 sq. ft. There are on the ground floor twenty-four indirect units in use of which twenty-two are in the showroom. Each of these contains four 60-watt tungsten lamps. The illumination on the working level is very uniform, being about 5½ ft.-candles everywhere. The consumption of electricity for the installation works out to rather under 1·8 watts per sq. ft., thus demonstrating that this is a case in which extreme economy in consumption of electricity is rightly made subservient to the production of a well-diffused and effective illumination in keeping with the standard of the goods supplied.

In an important showroom of this kind this is surely the right view to take. The cost of lighting is in any case but a small fraction of the total annual turnover, but it makes all the difference to the impression received by the visitor, whether such a showroom is satisfactorily lighted or no. The illumination provided, in this case, 5½ ft.-candles, is probably unusually high for a tungsten lamp installation.

Another feature of interest is the way in which the light from the illuminated ceiling enters into each corner of the room so that there is only quite a light shadow underneath the cars, and visitors can stoop and examine all the parts without their view being obstructed. For this reason indirect, and semi-indirect methods, seem to be very applicable to the lighting of rooms containing machinery and bulky objects, which have to be looked at from many quarters and even examined from below.

For the particulars given in this article we are indebted to the courtesy of the General Electric Co., Ltd., of London.

View of outside showing ground floor and first floor lighted up.

View of showroom, illustrating soft shadow from indirect units.

Two views of a Motor Showroom lighted by indirect units (Studebaker, Ltd., Gt. Portland St., W.).

(Photos. taken entirely by artificial light.)

SOME QUERIES ON DAYLIGHT ILLUMINATION.

On Tuesday, December 16th, 1913, a paper on "Problems in Daylight Illumination with special reference to school planning" is to be read at a meeting of the Society by Mr. P. J. Waldram.

Meantime the following series of queries has been prepared by the Sub-Committee of the Society charged with the investigation of this subject.

Anyone interested is invited to send information on these points to the Hon. Secretary of the Society (Mr. L. Gaster. 32, Victoria Street, London, S.W.).

(1) What measure would you suggest for the minimum actual illumination on the desk for reading in the schoolroom in full (midday) daylight ?

(2) What is the minimum intensity of daylight illumination on the worst-lighted desk in a schoolroom at which you consider that it becomes : (a) preferable, (b) essential to turn on the artificial light in the evening ?

(3) Do you consider a combination of daylight and artificial illumination to be, (a) satisfactory, or (b) inconvenient to vision ?

(4) Under what sky conditions or under what degree of sky brightness should the above minimum daylight illumination be obtained with a free horizon ?

(5) To what angle with the horizontal do you consider that surrounding buildings can be allowed to obstruct the sky hemisphere subtended at the window without materially affecting the light afforded by windows if the latter are of suitable width, and

(a) Subtend an angle of not less than 25° with the back desk,

(b) Subtend any lesser angle ?

(6) Is it desirable to specify that a certain vertical and horizontal angle of sky should be visible from all the desks in a room? What angles are necessary to ensure the minimum illumination under conditions of minimum sky brightness ?

(7) What are the recommendations for dimensions of schoolrooms in your country ? and what regulations are usual with regard to the window area of rooms of a certain size ? Do you consider it preferable to specify that the window glass (but not necessarily visible sky) should subtend a certain vertical and horizontal angle at the back of the room, and what angles would you suggest as desirable in order to obtain the minimum illumination under conditions of minimum sky brightness ?

(8) What is the best method of relating the illumination on the desk in the schoolroom with (a) the unrestricted illumination outdoors, (b) the sky brightness ? Do you think that such data constitute a practical method of comparing the access of daylight into various buildings ; and that they could be made the basis of a specification stating the size of windows and dimensions of schoolrooms ?

(9) What in your experience is the usual variation in daylight illumination met with respectively in the case of the worst and best-lighted desks in a schoolroom ?

(10) Are you in favour of unilateral lighting (windows on one side only) in a schoolroom ? Or do you consider additional windows in the other walls, or skylights (when practicable) also desirable ? In cases where bilateral lighting is unavoidable, do you consider that its effects can be mitigated by skylights or windows at a high angle ?

(11) Do you consider glazed partitions giving light from a well-lit room to one less well lit to be (a) a useful expedient, (b) preferable to a light coloured wall space ?

(12) Do you consider photometric tests in small models of buildings trustworthy as a means of determining the illumination to be derived from windows ; have you any records of such tests ?

(13) Is it desirable to recommend that the walls and ceilings in a room should have a certain minimum reflecting power ?

(14) Have you any other suggestions to make regarding the measurement of daylight illumination ?

TRANSACTIONS

OF

The Illuminating Engineering Society

(Founded in London, 1909.)

(The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.)

FIRST MEETING OF THE SESSION.

(Held at the House of the Royal Society of Arts (London) at 8 p.m. on Tuesday, Nov. 18th, 1913.)

The opening meeting of the Session took place, as announced above, on Nov. 18th, Mr. F. W. Goodenough being in the chair.

The minutes of the last meeting having been taken as read the Hon. Secretary announced the names of new members in the usual way. He remarked that there had been an increase of over 40 members during the vacation and the Society had obtained some most distinguished supporters. It would be observed that the names of Prof. Vautier, and Mr. Edward Allen and Mr. W. Duddell (respectively Presidents of the Institution of Gas and Electrical Engineers) had been added to the list of Vice-Presidents. At a recent meeting the Council had also added the name of their chairman, Mr. F. W. Goodenough, as a slight recognition of his services in bringing prominently forward the subject of illumination at the National Gas Exhibition. The Society has recently undergone a great loss in the death of one of its most distinguished Vice-Presidents—Sir Wm. Preece.

NEW MEMBERS OF THE SOCIETY.

The names of applicants for membership read out at the previous meeting on April 29th* were formally announced at the Annual Meeting, on June 3rd, and these gentlemen declared members of the Illuminating Engineering Society.

In addition, the names of the following gentlemen have been duly submitted and approved by the Council, and were also read out by the Hon. Secretary at the Annual Meeting:—

Vice-President:—

	Vautier, Prof.	Professor at the University of Lyons, President of the International Commission on Illumination. 3, Montel de Belmont, Lyons.

Created Vice-Presidents and added to Council:—

V.P. M.C.	Allen, E.† *Mem. Inst. Gas Engineers.*	President of the Institution of Gas Engineers, Liverpool United Gas Light Co., Duke Street, Liverpool.
V.P. M.C.	Duddell, W. *F.R.S., M.I.E.E.*	President of the Institution of Electrical Engineers, 56, Victoria Street, London, S.W.
V.P. M.C.	Goodenough, F. W.† *Mem. Inst. Gas Engrs.*	Chairman of Council, Horseferry Road, London, S.W.

Ordinary Members:—

Barker, H. Granville Kingsway Theatre, Great Queen Street, London, W.C. (4)

Behrens, Capt. T. T. United Services Club, Pall Mall, London, S.W. (4)

---

* *Illum. Eng.*, Lond. July, 1913. p. 386.

† Mr. Allen and Mr. F. W. Goodenough are already Members of the Council.

Brylinski, E.	Director of the Société "Le Triphase," member of the French Electrotechnical Committee, &c., 25, Quai Aulagnier, ASNIERES (Seine). (4)
Burt, C. H.	Electrical Engineer and Fittings Manufacturer, 195, Wardour Street, LONDON, W. (4)
Bussell, R. C.	Director of Blanchard Lamps (British), Ltd., 13, Gower Street, LONDON, W.C. (4)
Bussey, S. R.	Rose Bank, Vicarage Road, LEYTON. (4)
Chamen, A. D.	Electrical Engineer, Metro. Elec. Supply Co., Ltd., 16, Stratford Place, LONDON. (4)
Colquhoun, J.	1, Bisham Gardens, Highgate, LONDON, N. (4)
Copelin, A.	Works Manager, Special Lamp Dept., Edison and Swan United Elec. Light Co., PONDERS END, Middlesex. (3)
de Artigas, J. A.	Engineer and Managing Director to Luz Moore Artigas, Ltd., Spanish representative on the International Electrotechnical Commission, &c., 4, Arrieta, MADRID. (4)
du Chattel, J. van Rossum	Chief Engineer and Manager of the Municipal Gas Works, AMSTERDAM. (4)
Evans, L.	104, Gray's Inn Road, LONDON, W.C. (3)
Filliol, A.	Engineer to the Electric Supply Co. of Geneva, 3, Chemin Venel, Geneva. (4)
Fogg, O. H.	Engineer to the Consolidated Gas Co., 128, E. 15th Street, NEW YORK, U.S.A. (3)
Freeman, E. H.	Electrical Engineer, 20, New Bridge Street, LONDON, E.C. (4)
Heilig, G.	Officer in charge of the Birmingham Gas Department, Council House, BIRMINGHAM. (4)
Ives, R. A.	27, Byron Road, HARROW-ON-THE-HILL. (4)
Johnson, H. W.	Lecturer on Electrical Installation Work, Royal Technical Institute, SALFORD (4)
Laughton, E. C.	Asst. Manager, Incandescent Lamp and Fittings Dept., Siemens Bros. Dynamo Works, Ltd., Tyssen Street, Dalston, LONDON, N.W. (4)
Leal, J. P.	Mechanical Engineer, 3, Guildford Place, Russell Square, London, W.C. (4)
Luckiesh, M.	Physical Laboratory of the National Electric Lamp Association, CLEVELAND, Ohio, U.S.A. (4)
Macfarlane, G.	Secretary of Blanchard Lamps (British), Ltd., 50, Greenham Road, Muswell Hill, LONDON, N. (4)
Massé, R.	Director of the Société française d'Éclairage and de Chauffage par le Gaz, and other Companies, 22, rue de Calais, Paris. (4)
Maurice, F. J.	The General Electric Co., Ltd., Queen Victoria Street, E.C. (4) 80, Addison Way, Hendon, LONDON, N.W.
Meads, H. J.	Engineer to the British Graetzin Light Ltd. Chapter Street, Westminster, LONDON, S.W. (3)
Mullard, S. R.	Lamp Dept., Edison and Swan United Electric Light Co., PONDERS END, Middlesex. (3)
Noad, A. C.	Manager of the Lamp Department, Messrs. Watlington & Co., Ltd., Britannia House, 48, Milton Street, LONDON, E.C.
Ogley, D. H.	Royal Technical Institute, SALFORD. (4)
Palmer, R. H.	Advt. Manager, Welsbach Light Co., Ltd., King's Cross, LONDON, W.C. (4)
Pye, T. E.	Engineer and Manager of the City of Chichester Gas Co., Clovelly, CHICHESTER. (2)
Randall, E. L.	Blanchard Lamps (British), Ltd., 89, Bayham Street, LONDON, N.W. (4)
Reynolds, Dr. A. E.	Ophthalmic Surgeon, 15, Finsbury Circus, LONDON, E.C. (4)
Rhodes, S. G.	Engineer, Test. Dept., 117, W. 39th St., NEW YORK, U.S.A. (3)

Rootham, H. M.	Consulting Engineer, Craven House, Kingsway, LONDON, W.C. (4)
Short, S. T.	Elec. Engineers, 17, Annesley Avenue, HENDON, London, N.W. (4)
Stroud, E.	Lighting Engineer, 60, Welbourne Road, Merton Park, LONDON, S.W. (4)
Sutcliffe, H.	Engineer, 79, Brownlow Road, New Southgate, LONDON, N. (4)
Tooth, L. F.	Asst. Superintendent of the Commercial Gas Co. (Stepney), 34, Redbridge Road, Wanstead, LONDON. (4)
Watson, R.	Chief Engineer, The Gas Works, DONCASTER. (3)
Westlake, W. N.	Manager of the Exeter Gas Light and Coke Co., 11-12 East Southernhay, EXETER. (4)
Whyte, W.	Corporation Gas Works, ROTHESAY, Scotland. (4)
Wilkinson, H. T.	Managing Director of the Wardle Engineering Co., 196, Deansgate, MANCHESTER. (4)
Young, Dr. T. Meredith	Medical Officer of Health and Chief School Medical Officer to the Cheshire County Council, West Mount, CHESTER. (4)

Corresponding Members :—

C.M.	Kusminsky, Dr.	Chief Inspector of the Bureau of Standards, Vienna ; Vice-President of the International Commission on Illumination, 1, Alliertenstrasse, VIENNA.
C.M.	Lacombe, C. F.	Chief Engineer of Light and Power to the City of New York, 13-21, Park Row, NEW YORK, U.S.A.
C.M.	Niethammer, Prof. Dr. F.	Austrian Delegate to the International Electrotechnical Commission, K. K. Tech. Hochschule, BRUNN, Austria-Hungary.
C.M.	Weiss, M.	Chief Engineer, Zürich Gas Co., Delegate for Switzerland to the International Commission on Illumination, The Gas Works, ZURICH, Switzerland.

The Chairman then called upon Mr. Gaster to read his Report of Progress during the vacation. (See pp. 613-615.)

Subsequently the Chairman gave a short address in the course of which he alluded to the events connected with illumination at the National Gas Exhibition as follows :—

Illumination at the National Gas Exhibition.

THE CHAIRMAN :—I am sure that we are much obliged to Mr. Gaster for the interesting account he has given of the various occurrences during the vacation, of interest to all who have the welfare of illuminating engineering at heart. We are particularly interested in the formation of the International Commission on Illumination. Naturally, we must not expect too rapid results from the operations of such a Commission, but its formation is a good thing and we hope that it will go steadily ahead, and in time to come do much useful work.

It is now my duty to mention what was done at the National Gas Exhibition to forward the interests of scientific illumination. I am not going to refer to the exhibition at all as a gas exhibition ; I only just want to mention to this Society the papers which were read at the conferences held at the exhibition on subjects of general " illuminating " interest, apart from the specific interest of the gas industry.

At a Conference of Educationists on October 11th the President of this Society, Professor Silvanus P. Thompson, read read a most interesting paper on " Some Considerations on the Brightnesses of Lights," and gave a fascinating and, as usual with him, a most lucid account of the measurement of illumination and the relation between the intrinsic brilliancy of light and eyesight and comfort.

Then, following that, a paper by Mr. Gaster was read on " The Physiological and Mental Disadvantages of Unscientific Illumination," in which he referred to some of the conditions to be observed in the lighting of schools. I am sure you will agree that it was of considerable service to the cause of

scientific illumination that, at a conference that was largely attended by those interested in education, and was presided over by so well-known an authority in the educational world as Sir George Kekewich, such a paper should be read. Mr. Gaster emphasised the necessity for the application of scientific principles in the lighting of the schools, in which the rising generation are, in all too many cases, having their eyesight damaged at the present time through the illumination being very far from scientific. At the same conference a paper was read by Mr. Septimus Warwick, on behalf of himself and Mr. Austen Hall, Members of the Royal Institution of British Architects, on "The Lighting, Heating, and Ventilation of the School of the Future," and in that paper they drew attention to the Interim Report of the Committee of this Society which is inquiring into the question of the scientific illumination of schools. As the papers read at that conference will be very widely circulated to those interested in the subject of education, I think we may feel that a good deal has been and will be done to bring the question of scientific illumination before educational authorities.

Then on October 17th we were fortunate enough to have Lord Rayleigh presiding over a conference specifically devoted to the consideration of scientific illumination, and there Mr. Gaster read a paper, to which he has already referred, on "The Aims and Objects of the Illuminating Engineering Society." It was at this conference that the very interesting suggestion was made by Mr. Shadbolt (which, as we have already heard, the Council is considering) that we should hold provincial conferences of the Illuminating Engineering Society to bring the question of scientific illumination before the industries of the country more widely than it is possible to do by London meetings. It is hoped that we may be able to secure the interest of the public authorities in places such as Manchester, Birmingham, and Glasgow, so as to be able to hold meetings under the auspices of the authorities of these cities, and bring the question of illumination before the manufacturers and the medical and scientific authorities of these districts.

Next, Mr. Franklin Thorp, a member of this Society, read a paper before the same conference on "The Economy of Efficient Lighting," in which he emphasised the fact that good lighting, so far from being a luxury, is a necessity, an economical and profitable proposition, leading to increased and improved output in factories, and constituting a safeguard against accident. Dr. Meredith Young, Medical Officer of Health for the County of Cheshire, read an important and valuable paper on "Light and Sight." An abstract of the paper has already been published in the Journal of this Society, but the paper will be published in full later on, and copies will be available for the members of this Society.

Then finally, at a Conference of Manufacturers, presided over by Lord Weardale, on October 29th, Mr. Gaster, to whom we are indebted for the enormous amount of work that he did in connection with these conferences, read a paper on "The Economic Value of Adequate Illumination." This will be widely circulated amongst all manufacturers in this country, so that I think you will agree that whatever the National Gas Exhibition may have done for the particular industry in whose interests it was organised, a good deal was done in the interests of scientific illumination *per se*, without relation to any particular illuminant.

The Chairman then called upon Dr. James Kerr to give his account of the Fourth International Congress on School Hygiene (see pp. 616), and subsequently Mr. Dow read the paper by himself and Mr. V. H. Mackinney on "Shadows by Natural and Artificial Lights" (see pp. 619).

These papers and the discussion will be found reproduced *in extenso* in the following pages.

The Chairman, in closing the proceedings, announced that the next meeting would take place on Tuesday, Dec. 16th, when a paper entitled "Some Problems in Daylight Illumination with special reference to the Planning of Schools" would be read by Mr. P. J. Waldram.

A REPORT OF PROGRESS DURING THE VACATION.

(June—November, 1913.)

By L. Gaster, *Hon. Secretary.*

(Presented at a Meeting of the Society, held at the House of the Royal Society of Arts (John St., Adelphi, London, W.), at 8 p.m. on Tuesday, Nov. 18th, 1913.)

During the vacation there have, as usual, been a number of events of considerable interest to the Society; but as most of these have been referred to in the last few issues of the Illuminating Engineer, it is only necessary to make a brief summary of them in this report.

International Congresses and Exhibitions.

A feature has been the number of congresses at which attention has been devoted to illumination and the eye. At the International Medical Congress, held in London during August, papers were presented by two members of the Society: by Mr. J. Herbert Parsons (in the section of Ophthalmology) and Dr. James Kerr (in the section on Hygiene and Preventive Medicine), dealing respectively with "Affections of the Eye caused by Undue Exposure to Light," and the "Eyesight of School Children." In both these papers attention was drawn to the claims of good illumination, and the subsequent discussion showed that medical men are studying more closely the lighting problems.

Dr. Kerr was also present at the Fourth International Congress on School Hygiene, held at Buffalo, U.S.A., during August 25th—30th. As he has kindly undertaken to present a short note on the proceedings at the opening meeting, nothing further need be said on this point except to mention the excellent plan adopted by the American Illuminating Engineering Society of making this a joint meeting so that lighting engineers and the medical officers could confer together on school lighting.

The proceedings at the Seventh Annual Convention of the American Illuminating Engineering Society were summarised in the last number of the Illuminating Engineer. As usual, a series of excellent papers was presented, and the Convention appears to have proved quite as successful as in former years.

At the International Roads Congress held in London towards the end of June, a special section was devoted to road and vehicle lighting, and it was interesting to see how generally the view is now held that the lighting and upkeep of roads should be considered together. Even in regard to country roads several members pointed out that ultimately the lighting might be made a national affair, at all events in the case of the great highways. A series of important resolutions were passed dealing with these subjects.

The proceedings at the National Gas Exhibition were described in the last number of the Society's journal. Mr. F. W. Goodenough has kindly promised to say a few words on the subject. I think we, as a Society, should express our appreciation of the excellent opportunity of making our aims and objects known provided at the conferences held at this Exhibition, an opportunity which was afforded largely through the enterprise of our Chairman of Council, Mr. Goodenough. I may say that the Council, recognising the great services of Mr. Goodenough to the Society during the past year, has unanimously nominated him a vice-president. I am pleased to announce that he also consented to remain Chairman of the Council during this session. While referring to the Exhibition I should like to mention the admirable work of another member of our Society, Mrs. Cloudesley Brereton, to whose efforts as chairman of the Editorial Committee, the wide publicity given to illumination was largely due.

Work of the Society's Committees.

The report of the Joint Committee on School Lighting was frequently referred to in the conferences at the Exhibition, and has been widely reprinted and favourably commented upon throughout this country and on the Continent.

At the commencement of the vacation a sub-committee was appointed to consider

the subject of daylight illumination—a matter which, besides being of special importance in connection with schools, is also of general interest to architects. A number of meetings have been held and much information collected, and Mr. P. J. Waldram has consented to read a paper on the subject at the next meeting of the Society on December 16th.

The Joint Committee on the Street Lighting Specification is also continuing its work and is considering the revision of the draft specification put forward in Mr. Trotter's paper before the Society last April.

Another matter that is receiving the attention of the Society is the question of the avoidance of glare from shiny paper. Members will be interested to learn that it has been decided, from the first of next year, to make use of a mat art paper, free from gloss, for the official organ of the Society (THE ILLUMINATING ENGINEER).

THE INTERNATIONAL COMMISSION ON ILLUMINATION.

I come now to the most important event of the vacation—the formation of the International Commission on Illumination. It will be recalled that at the International Electrical Congress at Turin in 1911, a resolution was passed unanimously approving the formation of such a Commission, at the initiative of our Society; and that Dr. A. Lynch, M.P., in a question addressed to the Home Secretary in the House of Commons on May 16th last year, pointed out the importance of this resolution in connection with the proposed Commission on industrial lighting.

At that time it was anticipated that an entirely new Commission would have to be formed, in fact this Society has still a mandate to proceed on this line should it be desirable. But meantime, it has happily been found possible to form the Commission by suitably enlarging the membership and functions of the International (Zürich) Photometric Commission. This body was originally formed at the International Congress of Gas Industries which took place in Paris in connection with the Universal Exhibition of 1900. Its intention was to carry out researches on the photometry of gas lights, and to undertake researches on the practical applications of gas. A considerable amount of useful photometric work has been carried out at the Congresses of 1903, 1906 and 1911. But it was felt that the time had now come for the formation of a truly International Commission, not representative of any one illuminant, to which all questions of common interest to the lighting industry throughout the world could be referred.

Accordingly provisional National Committees were formed in the chief countries to consider this subject. In this country the Institutions of Gas and Electrical Engineers and the Illuminating Engineering Society co-operated, each nominating six representatives on the committee. The delegates from the Illuminating Engineering Society were:—Prof. S. P. Thompson, Mr. A. P. Trotter, Mr. F. W. Goodenough, Mr. Haydn T. Harrison, Dr. R. Lessing, and Mr. L. Gaster. The International Photometric Commission met in Berlin during August 27th to 30th. The National Committee in each country was invited to send delegates, the representatives from Great Britain being Mr. W. J. A. Butterfield, Dr. Colman (Institution of Gas Engineers), Mr. W. Duddell, Mr. K. Edgcumbe (Institution of Electrical Engineers), Mr. L. Gaster, Mr. C. le Maistre (Illuminating Engineering Society), and Mr. C. C. Paterson (National Physical Laboratory). After some discussion it was decided to form the International Commission on Illumination, and draft Statutes were agreed upon.

The Commission will be known as the International Commission on Illumination (Commission Internationale de l'Eclairage). The Commission has for its object the study of all questions affecting the lighting industry and of sciences related thereto, and the establishing by all appropriate means of international agreement on lighting matters.

The Executive Committees consist of the President, three Vice-Presidents, Treasurer and Hon. Secretary and two delegates from each country. Each country is to have equal voting power, and it was also agreed that on the committees there should be no preponderating influence due to any one illuminant.

It was arranged that each country represented could send up to ten delegates to the meeting of the International Commission on Illumination. A further

important clause in the Statutes provides that in countries in which an Illuminating Engineering Society already exists this body might be selected to replace the national committees and appoint two of its members to act on the Executive Committee. At the meeting in Berlin this course was actually taken by Germany, and the newly created Illuminating Engineering Society in that country did act as the National Committee. This very practical step has the advantage of bringing the questions to be discussed before the immediate notice of the body which is most closely interested and which is in a position to consider them impartially. It would therefore be desirable to nominate as delegates two members of the Illuminating Engineering Society, who are also members of the Institutions of Gas and Electrical Engineers, and these Institutions would naturally prefer to be represented by those of their members who have prominently identified themselves with matters of illumination. Our Society can justly claim to have originated the idea of the National Commission on Illumination, and has done much of the pioneering work in this direction. I venture to think that ultimately when the claims of our Society have been thoroughly established, and greater recognition given to our pioneering work in this direction, that the National Committee which is to be established will be a part of our organisation, and acting in close co-operation with the older established institutions in this and other countries.

The first President of the International Commission on Illumination is Professor Vautier, whose name is familiar to all those interested in illumination in this country as the President of the International Photometric Commission, which has thus become merged in the larger and more representative body. I am pleased to announce that Prof. Vautier has consented to become a Vice-President of our Society. As our list of new members shows, we have also received the valued support of a number of other authorities in foreign countries, who became interested in our work through this meeting in Berlin. I may add that the Vice-Presidents of the Commission, Dr. Bunte, Dr. Hyde, and Dr. Kusminsky, are all valued supporters of our Society. The Hon. Treasurer is Mr. Weiss, and Mr. C. C. Paterson has been elected Hon. Secretary. The wisdom of this choice will be appreciated, London, which is exceptionally well-fitted to act as a link between the Continent and the United States, becoming the official centre from which the business of the Commission is transacted.

It will be seen, therefore, that the international movement is making good progress. There are now in existence Illuminating Engineering Societies in Great Britain, Germany, and the United States, and we may expect to hear very shortly of the formation of a similar society in France. A preliminary step has already been taken in the issue of the new French journal, *La Science et Art de l'Eclairage*, devoted to the subject of illumination, under the direction of Prof. A. Blondel. Members will doubtless welcome this authoritative and responsible source of information on developments in France.

Enlarging the Membership of the Society.

Now in order that our Society may fitly take its place in this international movement, and in other pending developments, it is desirable for its membership to be considerably increased. During the vacation there was been an increase of about forty members, and what is equally satisfactory, the list includes many who are prominently associated with illumination in their respective countries, and whose support should be of considerable assistance in securing the co-operation of kindred bodies. I may make special mention of one step recently taken by the Council in this direction. An invitation has been extended to the Institutions of Gas and Electrical Engineers that their Presidents should be *ex officio* members of Council and Vice-Presidents of our Society. I am pleased to say that Mr. W. Duddell and Mr. E. Allen, the Presidents of these Institutions for the present year, have already kindly consented to act in this way.

I regret to have to record the recent death of one of our most distinguished Vice-Presidents, Sir William Preece. His name will be remembered as one of the very earliest pioneers in illumination

photometry, and from the first he had taken a keen interest in the work of the Society.

This opportunity may also be taken to mention another step that the Council are now considering. In the course of the discussion of the paper "The Aims and Objects of the Illuminating Engineering Society," read at a Conference at the National Gas Exhibition, the suggestion was made that the time had now come to form local branches of the Society. It is therefore proposed to appoint representatives in various districts to assist in forming the nucleus of local branches. It is hoped that before long we may be in a position to arrange for conferences to take place in different districts at which papers might be presented of special interest in that locality. Meantime it is hoped that members residing out of London will bear this development in mind and make a special effort to interest friends in the work of the Society, which is not only national, but international, in its scope.

SOME NOTES ON THE FOURTH INTERNATIONAL CONGRESS ON SCHOOL HYGIENE.

(Held in Buffalo, August, 1913.)

By James Kerr, M.A., M.D., D.P.H.

(Presented at a Meeting of the Society held at the House of the Royal Society of Arts (John Street, Adelphi, London), at 8 p.m. on Tuesday, Nov. 18th, 1913.)

The IVth International Congress on School Hygiene was held in Buffalo in August. There were so many sections to be dealt with and no papers printed beforehand that it is difficult to give a picture of the proceedings. A special section, arranged by Dr. Lucien Howe of Buffalo, who has done so much to direct attention in America to the conservation of vision, was almost entirely taken up with ophthalmic questions.

In the section which dealt *inter alia* with illumination the subject was well presented, although there was nothing striking emerged.

Perhaps the paper by Professor Ferree of Bryn Mawr, who had approached the subject purely as a psychologist, opened up new ground. He attempted to analyse the factors in illumination which most affected ocular efficiency, and shewed numerous charts of results. Actual intensity of light seemed of small import compared with even distribution. He concluded that with an evenly illuminated space fatigue was least, and that daylight was least tiring. His tests for fatigue came down finally to distinguishing between an "i" with its dot and a long "l." It was subsequently pointed out that these tests were not satisfactory as they did not involve factors of importance, such as the effect of shadows, on which the visibility of small objects largely depend, and that a test by threading needles might have given quite different results. The discussion ultimately turned mostly into the merits of direct and indirect lighting.

Dr. M. Gestettner of Vienna read a paper largely discussing the adaptation of the eye to light, and the value of slight changes when the light was poor. She pointed out the difficulties of daylight photometry with constantly varying intensity. She had used Weber's photometer, then a photometer of Prof. Kauer. About 3,000 measurements had been made in schoolrooms, with and without blackboards, and what also may be called whiteboards.

She used boards at the end of the room behind the teacher in the European way, and also on the right hand side of the

children opposite the window, the American way. No detailed measurements were given, but blackboards at the end made little difference. At the side they diminished desk-lighting from 12 per cent. to 18 per cent., an average of 15 per cent. White boards increased it almost to the same amount. She recommends white surfaces, and states that whilst the American plan is not good the European is unobjectionable.

The subject of blackboards also came up on the discussion of Luckeish's paper, on glaring paper and the difficulties it presented in largely nullifying the effect of good lighting, although well-distributed light also modified glare largely. He suggested tilting the blackboards to get regular reflection away from the children's faces. Green boards, brown boards and white rolls of paper were all suggested as improvements on the universal blackboard.

A stall in the Exhibition, arranged by the Illuminating Engineering Society, showed the effects of different systems of lighting, and the comparative results using matt printed surfaces, and steam-rolled glossy paper.

Dr. Alger dealt with illumination chiefly from its effect on the eye in causing glare from high intrinsic brightness, and strain from rapid variations.

The room in which the papers were read sometimes presented a most admirable demonstration of glare from adaptation of the eye. It was a room with three large windows behind the chairman and a couple of windows in each side wall next to the three other windows, the rest of the room was without windows. One could sit in this room in bright sunshine without glare being felt, but as one after another the windows were slowly closed for the lantern, the glare became evident, till with the last window it was quite painful, the eye having become adapted to the general darkened room.

Several other papers, including my own, dealt with illumination of the class-room in the light of present-day knowledge without presenting any great novelties. Dr. Weaver was very catholic in his views; so long as light was well distributed, and the artificial lights high above the children's heads, he was satisfied.

I dealt with glare as a primary and rare condition due to pathological charges in the retina, and a secondary common condition due to excess of peripheral illumination over that at the macula for which I assume the eye to be adapted. The importance of these considerations in connection with wall decorations and artificial lighting was mentioned. I advocated for daylight a minimum of 10 foot-candles, and for artificial light the suggestion of the Committee of this Society of a minimum of 2 foot-candles; as regards systems of lighting semi-indirect illumination seemed best for general school use.

In the discussion Dr. Myles Standish, who was chairman of the Boston Commission on School Lighting two years ago, expressed his complete concurrence with the suggestions.

Dr. Fitz of Long Island read a paper which was a critical review of methods of estimating illumination for school purposes. He left photometry on one side, and rightly thought that mere tests for visual acuity were unsatisfactory. He relied chiefly on geometrical methods, and showed an ingenious apparatus consisting of a small convex hemisphere of black glass, with which he estimated the square angular size of the visible sky from any place. It is doubtful whether it is practically useful, as what is really wanted is an equivalent reduced angular measurement, and in describing the instrument I showed here some time ago, I pointed out that all these measurements could be only very approximate, as when nearing limits so much depended on other factors, reflections and so forth, in addition to the actual visible area of sky.

Although the discussions were joined in by the Illuminating Engineering Society, the time was short and the subject did not receive full treatment.

A visit to America shows to what great use lighting may be put. The whole district about Buffalo depends for power and light on electricity transmitted from Niagara. The Canadian Government has retained rights over this power, and it feeds Toronto, 80 miles off, by lines which stretch on great standards that stride round the western shores of Lake Ontario. The hydro-electric lines

run down the centre of the Niagara peninsula as far as London (100 miles off). While there I was much struck with the alterations in pressure, the lights slowly waxing and waning in intensity without flicker.

Buffalo, on the other hand, through financial interests controlling the power, has to pay heavily. An interesting circumstance happened which one may relate to the Society. Whilst at a Reception at the Buffalo Club, about 10.30 p.m. a heavy thunderstorm began, all the lights went out, servants came running in with tapers, and lighted candles in sconces on the walls. I thought of going off, but was told that the streets would be dark and no cars running, as the power had been turned off at Niagara. It was so, and the whole of that city of 600,000 inhabitants was held up for 37 minutes by the thunderstorm.

On the other hand, two days after the Congress there was a Centenary Celebration of Commodore Perry's victory over the British on Lake Erie. At that time it was apparently quite a parochial affair, but the New York State has voted 150,000 dollars to celebrate the centenary. In the main street of Buffalo there were wood and stucco pillars about 20 feet high erected on each side at about 18 or 20 yards distance and festooned around and between with strings of coloured lamps. The illumination, indeed, resembled a river of light, which will remain a pleasing memory of this visit to America.

SHADOWS BY NATURAL AND ARTIFICIAL LIGHT.

By J. S. Dow and V. H. Mackinney.

(Presented at a Meeting of the Illuminating Engineering Society, held at the House of the Royal Society of Arts (John Street, Adelphi, London), at 8 p.m. on Tuesday, Nov. 18th, 1913.)

This subject is a very wide one. All that has been attempted in this paper is to collect a few photographs illustrating some interesting points, most of which deserve more detailed consideration. In order to show the importance of photographs of shadows I may mention particularly the case of factory lighting. It may happen that an inconvenient shadow leads to spoiled work or even an accident. Now, if in all such cases, photographs showing the shadow conditions by daylight and artificial light respectively were taken we should have a useful *record* of the causes of the mishap. But there are, of course, many other instances of the importance of shadows to the illuminating engineer: especially in connection with the artificial lighting of rooms having claims to artistic and architectural distinction.

The first illustrations show the inconvenience that may be caused by the shadows from head or hand owing to badly placed lights—a matter that is appreciated by lighting experts but still not sufficiently recognised by non-technical people. Fig. 1 shows the deep shadow cast by the head of a person bending over a drawing board when the light comes from the back, or even overhead. The

Fig. 1.—Showing deep head shadow cast over drawing board by light behind. Note also shadows from edges of drawing instruments.

T-square, indiarubber, ruler, &c., are slightly tilted to show the shadows at their edges which, although not immediately perceptible to a casual observer, would naturally cause trouble immediately one attempts to draw. This justifies the view that if local lighting is used for drawing boards, the light should preferably come from in front of the draughtsman.

The same point is illustrated in the series of four photographs assembled in Fig. 2. These show the effect of shadow when the light is respectively behind and facing the worker (*a*) by direct light from an unscreened lamp, (*b*) by indirect lighting. Only in the case of direct light from a lamp facing the observer is an inconvenient shadow produced; it is interesting to note that an indirect fitting even placed behind the worker does not cause a shadow that is marked to the eye. The difference in the sharpness of shadows is also seen in the appear-

(a) Bare lamp facing worker.

(b) Bare lamp behind worker.

(c) Indirect light facing worker.

(d) Indirect light behind worker.

Fig. 2.—Note the difference in the shadow from the chair and the objects on the wall by direct (bare lamp) and indirect light. It is only in the case of the direct light *behind* the worker that a marked shadow is cast on the board.

ance of surrounding objects, and particularly in the two general views of the table and surroundings shown in Fig. 3.

It should be explained that in taking the photographs shown in Fig. 2 the lights were arranged to give the same illumination on the table throughout (approx. 1 ft.-candle). In order to illustrate the depth of shadow cast by the head a reading of the surface-brightness of the lightest and darkest portions of the paper in each case was also taken. This led to a somewhat curious result, as shown by the following table :—

System of Lighting.	Surface Brightness.		Ratio.
	Brightest part of board ft.-c.	Darkest part of board ft.-c.	
Direct ..	1·06	0·38	1 : 2·8
Semi-indirect	1·06	0·5	1 : 2
Indirect ..	0·95	0·5	1 : 1·9

It will be seen that notwithstanding the far more distinct shadow from the direct system the numerical shadow-ratio is not so very different. Yet to the eye the shadow from indirect (and also the semi-indirect) units faded off so gradually as to be scarcely perceptible.

The above result, although surprising at first sight, is not unnatural when one reflects that a head near a drawing board must necessarily obstruct a considerable amount of light in any case. No doubt somewhat different results might be obtained according to the local conditions (nature of walls, height of ceiling, number of units, &c.). But the experience suggests that a satisfactory method of testing shadows should take account not only of the actual change in depth but also of the rate at which the shadow dies away. For this reason it may be doubted whether numerical data alone describe shadow conditions as successfully as a good photograph.

(a) Bare lamp.

(b) Indirect bowl.

FIG. 3.—A general view of the table referred to in Fig. 2. Note the difference in the shadow of chairs on the wall, under the table and beneath the drawers in the background.

Probably the best plan of all would be to secure a good photograph and supplement it by photometric readings of surface brightness in the way adopted by Mr. Eck in his experiment on the appearance of a flat disc and sphere in a room lighted by an indirect method.* It need hardly be said that such photographs need to be taken with considerable care as the result might easily be falsified by slight differences in exposure and development, and we are showing one slide illustrating the extreme possibilities in this direction.† Naturally all the photographs here reproduced were taken entirely by the artificial light in use at the time, and in each case every attempt was made to reproduce as exactly as possible the actual impression received by the eye. In some cases (*e.g.*, Figs. 4 and 12) it becomes necessary to sacrifice part of the picture in order to reproduce some essential feature.

Fig. 4. (a) Light coming from the right and casting inconvenient shadow over writing.

Fig. 4. (b) Light coming from the left: shadow does not fall on the writing and causes no inconvenience.

In Fig. 4 are seen, side by side, the effects of hand-shadow caused by light coming respectively from the right and from the left. The illustration justifies the old rule that the light on a desk should not (if one is right-handed) come from the right, for in this case an inconvenient shadow is thrown over the writing. For the purpose of the photograph the conditions were somewhat exceptional, an arrangement being deliberately adopted which gave a very dense shadow. (In these photographs the essential point was to bring out the shadow on the board; if one exposes for this correctly, the head and shoulders of the writer naturally come out rather dark.)

Such points as those roughly illustrated in the previous photographs must be met with, in a more complex form, in many industrial operations, where the shadows cast by moving tools, cutting edges, &c., are highly important. A series of photographs showing the results of badly placed or imperfectly screened lamps in factory lighting would

* Illum. Eng. Lond., Vol. IV, 1911, pp. 457, 593.

† This refers to the photograph of a house, taken by day and night, Illum. Eng. Lond., Nov., p. 576.

be most useful: but they deserve a separate paper. Perhaps some other member of the Society will take this up.

It should be remembered, too, that different conditions are met with when there are a large number of units. With direct lighting we then get multiple shadows.

Fig. 3 aptly illustrates the fundamental difference between the shadows cast by indirect lighting and by an unscreened source in an ordinary room. The next illustrations show this more completely. One of the most striking features of indirect and semi-indirect lighting is the manner in which the light gets into corners and underneath tables and other furniture. This is clearly shown in the photograph of a motor showroom reproduced in Fig. 5. The illumination here was exceptionally high and the units relatively close together. It will be seen that the chassis in the foreground casts scarcely any shadow on the floor at all. In a motor showroom, where visitors are constantly stooping to examine the machinery under the cars, this is a decided advantage and the same doubtless applies to most rooms in which large and complicated machinery has to be examined. In Fig. 6 we have a shelf of books, illuminated by direct light from a lamp in a prismatic reflector mounted on the ceiling. Here again the effect of good diffusion from the white ceiling is shown in the fact that the deep recesses are comparatively well illuminated. There is, however, a marked "cross shadow" due to the direct light. In order to illuminate a series of pigeon-holes successfully good diffusion is very necessary. Direct lighting, particularly by lamps in opaque reflectors immediately overhead, is of little service, as the inside of the recesses is left in dense shadow. This is one objection that may be raised to the local lighting of compositors' frames, which answers excellently for the type on the frame where the compositor is working, but is not of much help for the drawers below the level. Probably the best method of meeting this problem would be by a combination of local shaded lights over the frame with a certain amount of well-diffused general illumination.

The next two photographs (Fig. 7) are intended to show the characteristic difference between daylight and night illumination in the streets. The photograph on the right was taken on a misty day with a white sky. Although the head, being bent down, is in partial shadow, there is nothing like the contrast that one finds in the left hand view, where half the face is brightly lighted and the remainder in dense darkness. Note also the shadows from the legs of the tripod cast by the street lamp, which do not occur by daylight. Here again, there

Fig. 6—This shelf is lighted by a lamp in prismatic reflector fixed direct on the white ceiling. The diffused light finds its way into the recesses, but a distinct cross shadow caused by the direct component can be clearly seen.

is room for an entire series of photographs showing the conditions, as regards shadow, of our present methods of street lighting. In the streets, as in large halls, it is difficult to produce an impression of bright illumination even by the use of very powerful lamps. For the effectiveness of the lighting is considerably limited by the fact of so little assistance being derived through reflection from surroundings. Experience shows that an object has to be

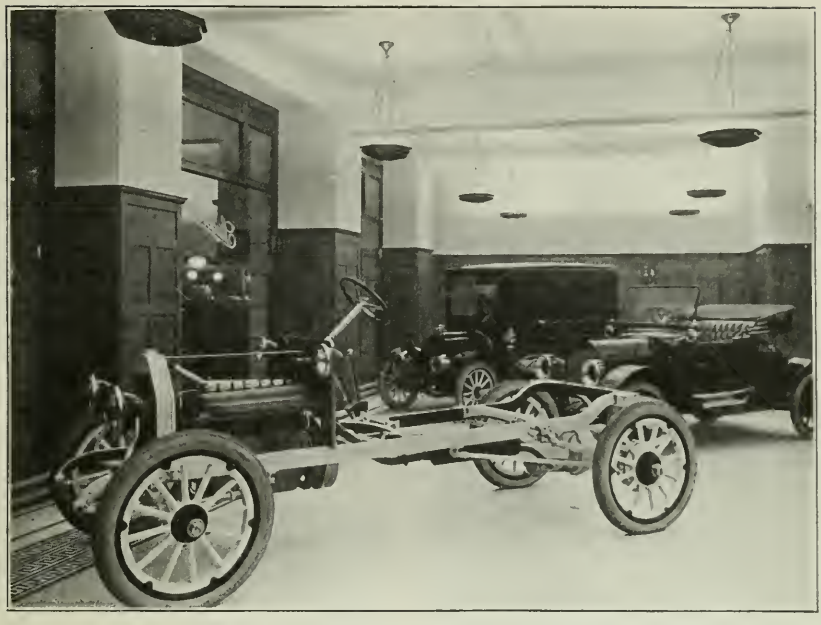


FIG. 5.—Indirect Lighting in a Motor Car Showroom. Note the very light shadows cast under chassis in foreground.

(a) Misty daylight.

(b) Artificial light.

FIG. 7.—Note well-diffused light and absence of shadow from person and legs of tripod by daylight. By the light of the street-lamp half the face is in deep shadow; well marked shadows are also cast by body and tripod legs.

illuminated from many different directions in order to be properly distinguished. In the street, where powerful units are placed at considerable intervals, this can rarely be the case, and in some instances the dense shadows cast by moving vehicles may be very misleading to the pedestrian crossing the street.

Having now shown by several examples the value of well-diffused illumination let us now turn to a case in which light coming from all directions is just what we do *not* require. Fig. 8 is a photograph

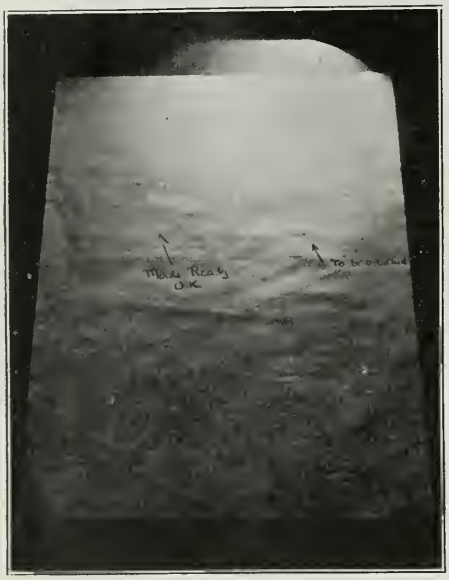


Fig. 8.—A "lay-off" sheet in the printing office, preferably illuminated by oblique light so as to show up the impression of type.

of an inclined board, lighted by an adjustable lamp in an opaque reflector, which is used by the printers of this journal when examining the "lay-off" sheet. When the trial sheet is removed from the machine it is necessary to examine closely the impression of the type and the blocks in order to ensure that the pressure is just right. Otherwise if the pressure is too great, the type will press too much on the paper and will show through on the reverse side of the page. The printer therefore examines this reverse side and the marks on the paper here displayed indicate where changes are required.

Now in order to show up these irregularities in the surface what one requires is light striking the paper very obliquely. In the illustration the impression of the type most remote from the source (and therefore struck by the light most obliquely) is clearly seen; but near the source where the rays strike the paper at angles nearer to the vertical one cannot see the projections nearly so well.

No doubt a similar method would be employed by paper experts in examining the gloss on paper or searching for small irregularities in its texture. To a person reading a book in the ordinary way, light striking the paper at a small angle of incidence is most convenient, and very oblique rays, which show up the defects, are objectionable. But to the expert, searching for these defects, the exact contrary condition is desired.

It is a question worth asking whether, in the examination of fine worsted, or various qualities of cloth, the same reasoning might not apply. For the expert in examining such materials is guided very largely by small irregularities in their surface, and one would be inclined to think that these could best be displayed by oblique rays coming from a source of small dimensions, and therefore casting fairly marked shadows. The depressions in a piece of quilting or knitted work would presumably show up better in these circumstances than if the light struck the material from all directions. Perhaps, too, the same would apply to cloth having a complex pattern in different materials, such as shot or broché silk, or velveteen, the appearance of which varies much according to the angle from which it is illuminated.

This is another problem which deserves more detailed discussion and might well be taken up by the Society. It seems to be a fact that most people engaged in such operations as knitting and sewing prefer a strong local light—possibly because they can then examine small differences in texture more readily by moving the material and so altering the incidence of the light.

The series of illustrations shown in the next few figures might form a starting place for further experiments. The small box shown was illuminated in two distinct ways: (A) by direct lighting with black surroundings; (B) by indirect lighting

FIG. 9.—Showing sharp shadow on the left, soft shadow on the right, thrown by "shadow tester."

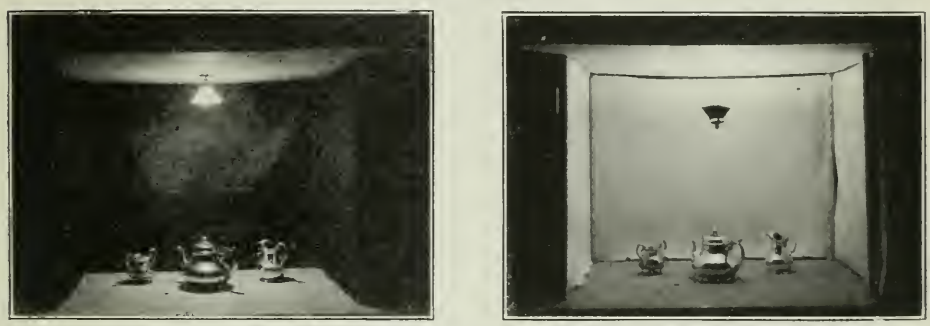


FIG. 10.—Note difference in shadow underneath the silver, also the "reversal effect" of its general appearance, some of the dark parts on the left appearing bright in the right hand view and vice versa.

FIG. 11.—Showing the value of oblique direct light in bringing out broché silk and velveteen patterns and showing the folds in material.

Various objects in small booth illuminated by :—

(a) direct light with dark surroundings
(b) indirect light with light surroundings.

with white surroundings. By this means one gets a complete contrast as regards shadow; in fact a much greater one than would usually be met with in practice. In Fig. 9 the difference in shadow-conditions is illustrated by means of the small shadow-tester described by one of the authors in a paper before the Society early this year.* In Fig. 10 we have some silver shown under similar conditions. The difference here is not so marked, the chief distinction being the much deeper shadow under the object by direct light. But it seems possible, especially with more distant lights, that pure indirect lighting might not be so good for the illumination of highly polished objects as direct or semi-indirect systems. For in order to show off goods of this kind one relies upon the sparkle produced by reflected images of lights in their surface. And unless one has somewhere in the room sources having a fairly high intrinsic brilliancy one can hardly expect to get marked sparkle of this kind. It may be added that the photographs hardly illustrate completely the distinction in this respect, as observed by the eye, for there is a natural tendency for these bright points of light to be over-exposed—a condition which one can hardly avoid if the exposure is adapted to show up the background satisfactorily.

Fig. 11 shows the appearance of a series of specially selected samples of cloth. The folded hanging strip in the centre of the picture is a piece of brown velveteen, the two side pieces consist of broché silk, and the material in the foreground is an ordinary camera cloth. It will be seen that the folds of the cloth and the pattern are decidedly more distinct with the direct lighting; and it would seem that light coming from all possible directions seems to obliterate to some extent glossy patterns on a mat ground and, indeed, most patterns that depend upon difference in the degree of "matness."

The problem when to aim at diffused illumination, and when to use uni-directional light, also occurs in connection with the general lighting of interiors. For example it does not seem to be definitely settled what variety of shadow is best adapted to showing off statuary, carving, &c. A special instance is afforded by the white embossed friezes used in many drawing rooms, the details of which, when illuminated by light coming from all directions, are naturally not so well marked as if lighted solely by oblique light. On the other hand it is sometimes contended that the effects produced by the latter method although more pronounced, are also unnatural. An opportunity was kindly afforded for a photograph to be taken of the entrance hall at the Savoy Hotel where the white frieze is illuminated by concealed cornice lights, in addition to the general illumination by semi-indirect units. A view of this room is shown in Fig. 12. The lower part of the room appears much darker than it really is in the photograph, since the exposure was selected with a view to bringing out the details of the frieze and was therefore hardly sufficient for the darker objects It will be seen how, in this case, the extra lighting of the frieze gives distinction to the room and relieves what might otherwise have been a somewhat flat effect. Another point to be noticed is the shadow of the cross beams on the ceiling. It is rather a debatable point how to avoid such shadows when indirect or semi-indirect methods are used with a ceiling of this description. Doubtless the shadow would be less pronounced if the units were hung somewhat lower; but in this case the lights themselves might be exposed to view.

In Fig. 13, which illustrates the appearance of the front of White's Club in St. James's Street, as seen by daylight and by artificial light on Coronation night, we have again an instance of the value of oblique rays in showing up mouldings. The artificial lighting of the face of the building was in this case obtained from two lines of concealed tubular lamps in trough reflectors, which were specially shaped to give an even illumination. It will be seen that the mouldings stand out in much stronger relief and are much more noticeable by night than by day. Some authorities seem to dislike the use of oblique lighting to show off surface ornaments of this kind, arguing that the effect produced is quite distinct from that characteristic of daylight, and therefore unnatural. This is doubtless a matter

* Illum. Eng. Lond., March 1913, p. 140.

of taste but there would seem to be no inherent objection to the method if the general impression is pleasing; it may be added that many of the most striking effects in the case of buildings seen by daylight are those produced by the inclined rays and lengthened shadows caused by the setting sun.

Finally we have in Figs. 14 and 15 an example of another characteristic difference between natural and artificial illumination. By the courtesy of the Allan

Fig. 12.—A view of the Hall at the Savoy Hotel. Note the special oblique lighting to show off the carving on the frieze. (The lower part of the room appears somewhat darker than it should be, as the exposure was necessarily limited in order to get the details in the frieze.)

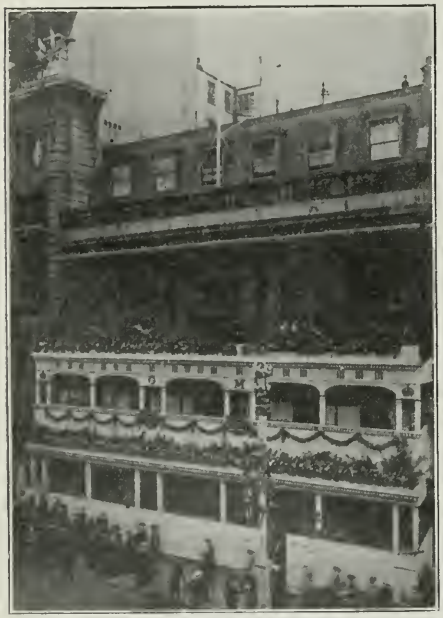
Photo. taken by daylight.

FIG. 14.—A view of the office of the Allan Line (Cockspur St., London, S.W.), by daylight. The pillars stand out *light* against a dark background, and the interior of the arch is *lighter* than its surroundings.

Photo. taken entirely by artificial light.

FIG. 15.—The same view by artificial light. Note the reversal of shadow. The pillars nowappear *dark* against a light background, the inside of the arch is now *darker* than its front face instead of lighter; and even the grooves in the pillars appear as dark lines instead of light ones.

Co. we were granted permission to take these two views by day and by night in the office of the Company in Cockspur Street. We selected this as an excellent example of the "reversal of shadow" by artificial light. In the view taken by daylight the pillars stand out white against a dark background, while with the artificial light we get an exactly opposite effect, due to the lamps concealed behind the pillars. The arch on the right shows a similar effect, the interior being brighter than the front surface during the day but darker by night. [Several slides, lent by Mr. T. E. Ritchie, were also shown, illustrating the difference in appearance of the hall at the Allegheny Soldiers' Memorial, Pittsburgh, by day and artificial light. A notable feature in this case was also the reversal in the shadow effect of the pillars.] Here again we find that some writers assert that these shadow reversals are unnatural and should be avoided. Yet it must be conceded that the concealed lights shown in Fig. 15 have a charming effect on which we must compliment the architect, Mr. A. T. Bolton, F.R.I.B.A.), and it might be urged that the artificial lighting of architectural features is a new field. Is it necessary for the effects characteristic of daylight to be imitated? Seeing that artificial lighting is itself radically different from daylight in its distribution and arrangement it seems unreasonable to try and force it always to give the same kind of shadows.



Daylight.

Night time.

Fig. 13.—Showing the appearance of White's Club (St. James's St.) by daylight, and the frontage illuminated by lamps concealed in trough reflectors on Coronation Night. Note the value of the oblique light in showing off carving on the front of the building.

Some of these architectural points are also worthy of special discussion. Indeed the more one examines and considers these matters the more one is struck by the important part played by shadow in almost all problems of artificial lighting. In its very first session this Society promoted a discussion on the subject of glare, the avoidance of which is now recognised to be such an important feature in artificial lighting; subsequently there were discussions on the measure-

ment of illumination, which are leading towards the prescription of certain intensities of illumination for various purposes in daily life. It may be suggested that the shadows caused by artificial light would provide yet another fruitful field for study and that the consideration of these three factors would enable us eventually to solve the great majority of problems in artificial illumination.

At the conclusion of the paper Mr. Dow referred to several exhibits of interest, including a form of table fitting with a revolving hexagonal frame, illuminated by the lamp inside. The frame contained positives of photographs of a number of lighting installations, backed by opal glass. It was pointed out that illuminated pictures of this kind should give a more effective picture of an installation than a photographic print, since the degree of contrast (which in a print does not as a rule exceed 30 : 1) approached more nearly that found in practice.

Another exhibit was a series of enlargements of several of the photographs exhibited, reproduced by a novel process direct on wooden panels.

Finally Mr. Dow showed a series of photographs of shadows kindly lent by Mr. M. Luckiesh, illustrating the work on this subject being carried out in the United States.*

Discussion.

The Chairman expressed his interest in the photographs submitted. Photography by artificial light might be very useful to the illuminating engineer, if carried out scientifically; but evidently it might also be deception carried to a fine art. In fact, it could fulfil all the qualifications that were required of an expert witness, according to the definition that had been given of that particular professional.

Mr. Dow had referred to one point that interested him, and that was the question of people who had to work with dark materials, worsted, &c., preferring small units of light near the work to good general diffusion of light. Mr. Dow had suggested that the explanation of it might be the ability to get the light upon the work at varying angles easily. That no doubt had something to do with it, but was it not also a possible explanation that when one was working in a way calling for close application to the work in hand, one liked to be able to look away from the illuminated work to something that was considerably darker? If one employed general illumination where this fine work had to be done, the eye got no relief by looking away from the work to the rest of the room, because the illumination was the same everywhere. He believed that the sorters in the Post Office almost went on strike when the authorities substituted good general illumination for local illumination upon the sorting work, because they found that the eye got no relief by looking away from the letters to the surroundings, whereas with adequate light on the work one was able to get some relief for the eyes by looking away from the illumination on the work to the very much less intense light in the room generally. That might be a partial explanation of the preference for small units of light in work calling for close attention.

Mr. T. E. Ritchie said that the Society was much indebted to the authors of this paper because the subject of shadows was a very important one. Reference had been made to the work of Mr. Eck, and the photographs published by him which he (Mr. Ritchie) thought showed the first attempt to obtain commercially from artificial lighting used under ordinary working conditions shadows approximating to those obtained in the same rooms by daylight.

Mr. Ritchie explained that since the installations in question, much had been done in this direction and proceeded to show a series of illustrations of a gymnasium and a museum lighted respectively by daylight and artificial light. He pointed out that the shadows obtained in the two cases were very similar both in degree and in density (see p. 633).

There was one very important aspect suggested by the paper. He thought that, having regard to the very great value of Photography in Illuminating Engineering, the time had arrived, when at all events

* Mr. Luckiesh's experiments are described on pp. 636, 637.—Ed.

for the purposes of the Illuminating Engineering Society, we should demand more accurate and scientific work in connection with shadows and information relating thereto and photographs thereon, than had been presented in the past. This point was all the more vital because, as the authors had pointed out, it was, perhaps, often difficult to determine shadow value by a purely photometric method and to present this information in the form of a ratio; but there was also no doubt that it is impossible with the best intentions in the world always to express them accurately in a picture. Mr. Ritchie thought, therefore, that it would be of great assistance to those interested, if it was possible to fix definitely the question of the correct expression of shadow values photometrically, and merely to use the photographs to indicate their direction and character, which, of course, could not be done in any other way.

Mr. Ritchie then proceeded to show a slide illustrating an experiment bearing on this point. In the photograph a shadow was seen cast by a small box. In the various illustrations of this the source of light was unaltered, the shadow was unchanged photometrically, the exposure was identical, and the only factor that was varied was the development. In one series of illustrations three shadows having apparently almost identical depth were visible; whereas if the density of the shadow on the left were taken as *one* the second one represented *twenty*, and the third one *forty*. In the other series a shadow of the same density appeared as of three widely different depths. Changes in exposure and in the printing process adopted might introduce other variations. It was evident, therefore, that by modification of the conditions, which might easily be unconscious, differences in actual results could be masked; yet to the casual observer such photographs would be taken to represent quite a possible result. He, therefore, thought that it was most desirable that definite information as regards the conditions under which the photographs were taken should be given, and he hoped that the authors would be able to suggest some method which might, after possibly further discussion, form the basis of uniform work in this direction.

Mr. Haydn T. Harrison referred to the photographs shown some time ago by Mr. Eck, and to some remarks which he himself made at that time on the question of shadow. Mr. Eck, it would be recalled, suspended a white disc and also a sphere and lighted them by indirect lighting. He (Mr. Harrison) had handed the published results and the photograph to three separate people and asked them to say which was the disc and which was the sphere, but they were unable to be certain. Mr. Dow and Mr. Mackinney had referred to this matter. The point he wished to emphasise was that there was no difference between a sphere and a disc if there was no shadow; but if there was shadow the sphere began to appear as a sphere and the disc as a disc, and the degree by which they were distinguished was in proportion to the degree of shadow.

He congratulated the authors upon the very valuable photographs which they had shown, but he thoroughly agreed with the last speaker that photographs might be most deceptive things; but fortunately these were taken with a different object. This was a point on which, he was glad to see, the authors had laid stress. There was one point with which he did not agree, namely, the authors seemed to infer that it was possible to obliterate any inconvenience caused by dense shadows, merely by diffusing the edge of the shadow, but if shadows cast were of large areas and very dense it was equivalent to putting that area of the room into comparative darkness which was to be avoided.

On the other hand some shadow was important to bring out the relief of solid objects.

He had heard it suggested that the whole object in streetlighting was to produce shadows, because one could often see a shadow more easily than the object producing it. This was perfectly true, because the object might be about the same colour as the road, and would therefore be difficult to distinguish without the shadow which would be darker. For the illumination of letterpress or drawings there was no object in having shadow because they were working in flat surface; but in bas-reliefs and similar cases such as

Daylight photograph showing positions and character of shadows. Note shadows on floor and compare with those shown in artificial light photograph below.

Shadow Ratio. measured mid-day 26.11.13.

$$\left(\frac{\text{Min. illumination in shadows under cases at left-hand side.}}{\text{Max. illumination in centre of passageway shown in foreground of photograph.}}\right)=11{\cdot}5$$

Artificial light photograph of room shown above, showing positions and character of shadows. Note shadows under specimen cases and compare with daylight photograph above.

Shadow Ratio

$$\left(\frac{\text{Min. illumination in shadows under cases at left-hand side.}}{\text{Max. illumination in centre of passageway shown in photograph.}}\right)=16{\cdot}7$$

those exhibited by Mr. Dow, the object might appear quite flat until the light was directed on it at an angle to produce shadows. This Mr. Dow had demonstrated by tilting the sample of bas-relief. With an evenly diffused illumination coming from all directions a shadow was not produced, and that was the point which he raised in the discussion upon the disc and sphere.

Mr. R. J. Wallis Jones said that the photograph shown by Mr. Dow of the entrance hall of the Savoy Hotel was of special interest to him as he was the engineer responsible for the lighting of this room. There was a particular object in designing the lighting of that frieze. It was a particularly deep frieze, and he had a special arrangement of tubular lamps to throw the light in an upward direction so as to get the correct shadow effect. He thought this installation was a very good example of the point which Mr. Dow had so clearly brought out.

Mr. Leon Gaster said that he appreciated the enormous amount of work involved in the paper. The use of photography in order to secure a correct representation of lighting conditions was a most important matter, and he would like to make special reference to one instance of this mentioned by the authors —the appearance of shadows in factories by natural and artificial light. It had been said that at the period in the evening when the twilight came on, and the artificial light began to be used, the amount of spoiled work was exceptionally great. One possible reason was that the shadows cast by artificial lighting were rarely the same as by daylight; if the shadows were thrown in an inconvenient direction this would account for many mistakes, and might even be the cause of an accident.

Now as a rule it is not possible to see the natural and artifical lighting conditions in a factory simultaneously; one can only try to remember what the daylight was like before the artificial light was turned on.

In such cases a photograph accurately comparing the conditions of shadow by natural and artificial light might indicate the defects of lighting responsible, and thus lead to most useful conclusions.

Mr. J. S. Dow and Mr. V. H. Mackinney (in reply):—

Much of the discussion seems to have turned on the trustworthiness of photographs in illuminating engineering. Seeing that we are so closely interested in the impression received by the eye, the utility of pictorial methods can hardly be doubted. A photograph, even if not absolutely exact, will show in a few minutes what would take a long time to explain verbally.

On the other hand photography, like Art, has its limitations. There are some conditions of light and shade which cannot be reproduced exactly, either on canvas or on a photographic print. Very frequently the variation in brightness in an interior is far greater than is reproducible on a photographic print, where the range of tone rarely exceeds 30 : 1. The shadows mentioned by Mr. Ritchie (40 : 20 : 1) represent a case in point. Much must be left to the judgment of the photographer. He should have a clear recognition of what the photograph is intended to show, and which are the features on which attention should be mainly concentrated.

Naturally, in interpreting photographs one should assume the good faith of the operator. Everybody is aware, and we have purposely illustrated this point in the paper, that photographs can be faked. But it would be as illogical to condemn photographs on this ground, as it would be to refuse to admit the value of painting because some people are colour blind.

We agree with Mr. Ritchie that in cases where correct appearance of shadow is of scientific importance it is well to supplement the photographs by illumination data, and particularly by surface brightness measurements of the various objects shown in the picture. On the other hand there are circumstances in which this method is not readily applicable, and other cases again (such as the drawing board illustrated in Fig. 2) where it hardly gives a true measure of the visual effect. Mr. Harrison alluded to this point. Of course, he is quite right in saying that a very dense shadow may make the details indistinguishable even though it

fades away very gently. Our comment was only intended to apply to the particular case discussed.

The Chairman alluded to the value of strong local lighting in concentrating the attention of the worker. No doubt this is one explanation why some people prefer local lighting with shaded lamps. But it may be suggested that there are other factors, such as the inclination at which the rays strike the illuminated surface.

Mr. Harrison referred to the "silhouetting effect" in the streets, an effect which was pointed out in a recent paper in the United States by Mr. P. S. Millar. No doubt, objects in the streets are sometimes seen in this way; nevertheless it must surely be admitted that a method of lighting in which objects are seen black against a bright background is by no means an ideal one, and it is probable that in some cases the dense shadows cast in the streets by moving vehicles have a distinctly misleading effect.

Mr. Wallis-Jones referred to the lighting in the lounge at the Savoy Hotel. We selected this as a good example of the use of inclined rays to illuminate friezes. The installation seems an excellent one, on which Mr. Wallis-Jones may be congratulated, and the combination of suspended bowls and frieze-lighting produces a very pleasant effect.

The Illuminating Engineering Society.

(FOUNDED IN LONDON, 1909.)

OFFICIAL ANNOUNCEMENT OF NEXT MEETING.

(To be held in the House of the Royal Society of Arts, 18, John Street, Adelphi, London, at 8 p.m. on Tuesday, Dec. 16th, 1913.)

At this Meeting a paper will be read by Mr. P. J. Waldram, F.S.I., entitled: "Some Problems in Daylight Illumination, with special reference to School Planning."

Copies of the paper can be had on application to the Hon. Secretary (Mr. L. Gaster, 32, Victoria Street, London, S.W.).

THE IMPORTANCE OF DIRECTION, QUALITY AND DISTRIBUTION OF LIGHT.

By M. Luckiesh.

(Abstract of a Paper read before the American Gas Institute, October, 1913.)

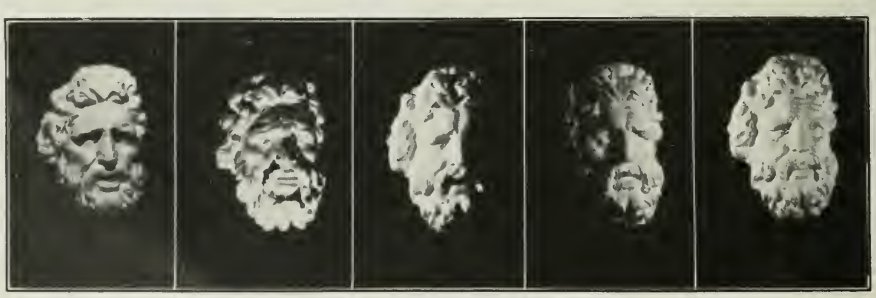
In a paper on the above subject read at the Eighth Annual Meeting of the American Gas Institute last October, Mr. M. Luckiesh showed a number of illustrations illustrating the effect of shadows on sculpture, and he has kindly sent us copies of these for reproduction. This series of photographs was also exhibited by Mr. J. S. Dow at the last meeting of The Illuminating Engineering Society (London).

In lighting statuary the question of shadows is of considerable importance, and the problem how the artificial light ought to be arranged in order to give the best effect is one that needs to be carefully studied by the lighting engineer.

Artificial light (Indirect). Artificial light (Direct). Daylight.

Fig. 1.—Showing different appearance of casts of a man's head by light coming in various directions.

Daylight illumination in a room is not always ideal, and its utility depends greatly on the way the windows are arranged. For example, in Fig. 1 is shown a cast of a man's head illuminated



Above. Below. Side. Side. Direct on right. Diffused on left.

Fig. 2.—Effect of light coming in various directions.

respectively by indirect and direct artificial lighting and by daylight. The room contained two windows on one side of the room and one on the other. The plaster head was hung 5 ft. from the floor and facing the wall containing one window. The walls and ceilings had a reflection coefficient of 40 per cent. It will be seen that, in this case, the effect of the artificial lighting is distinctly better than daylight, which caused part of the head to be left in shadow.

The importance of good diffusion in artificial lighting is very evident. Light coming from one direction only is apt to distort the appearance of a face. This is brought out very clearly in Fig 2, which represents a series of photographs of the head illuminated successively by light coming from above, from below and from the side.

A rather different problem is the illumination of low relief casts. The most ideal method would doubtless be to light each exhibit in a gallery separately in order to make sure of getting the best effect. But where there are many objects to be shown and this method is not practicable, the best system, Mr. Luckiesh suggests, would be to arrange the objects in a long narrow room lighted by a series of windows and by artificial lights from one side of the room. The reflection coefficient of walls and ceilings should be carefully considered in order to make sure that the diffusion is sufficient but not excessive.

It need scarcely be said that in revealing architectural effects some of these points are very important indeed. As an illustration of how mouldings may be altered, Mr. Luckiesh shows a capital lighted respectively from above and below (see Fig. 4). It will be seen that the appearance is quite changed, and a curious reversal of shadow is obtained on some parts of the object.

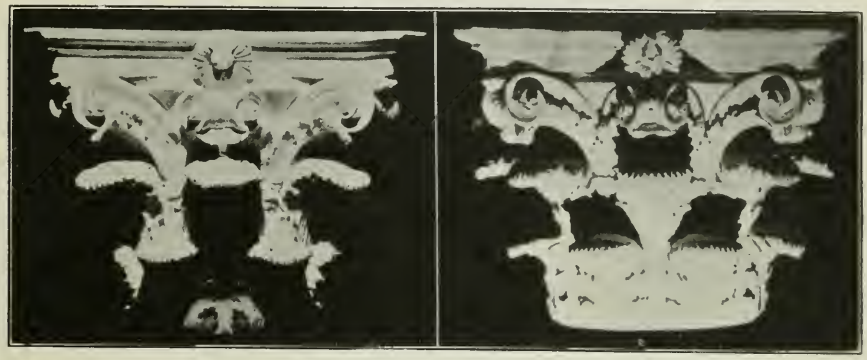


Fig. 3.—A capital lighted from above and below.

Fig. 4.—Showing effect of direction of light on an illuminated frieze.

In the remainder of the paper Mr. Luckiesh refers to the effect of direction of light and colour value on the appearance of pictures. This is a matter to which we hope to return shortly.

CORRESPONDENCE.

POLAR CURVES OF GLOBES, SHADES AND REFLECTORS.

DEAR SIR,

We notice in the last number of the "Illuminating Engineer" a letter in your columns on the above subject.

We take this opportunity of stating that we are entirely in agreement with your correspondent's remarks. When publishing polar curves of our units we have always been prepared to explain the conditions under which they are obtained. Although the testing arrangements in the different laboratories owned by and connected with this Company are exceptionally complete, and a skilled staff is engaged in continually studying this question, we have frequently had confirmatory tests carried out at outside institutions, such as the National Physical Laboratory in this country and similar institutions on the Continent and in the United States.

There is one other point which we would emphasise, namely published diagrams, besides giving the polar curves derived from the unit as a whole (lamp and shade or reflector combined) should also give the distribution curve from the bare lamp; only in this way can the effect of a globe or reflector be properly judged. A curve of the unit alone, especially when given without any figures indicating the c.p., is not of much value and may very often be misleading.

Believe me, Yours faithfully,

HOLOPHANE LTD.

DEAR SIR,

Under the above heading, "An Engineering Correspondent" has raised an important matter in your November number.

Presumably the object of manufacturers in publishing polar curves is to indicate the performance of their wares, and if this be the case every effort should be made to render such curves truly and fully descriptive. Among the catalogues and advertisements of glassware and lighting fixtures now being published, however, one may find polar curves without candle-power scales, devoid of data as to gas or electricity consumption, and showing in no way how the curve of the bare illuminant is modified by the particular device under consideration.

Now it is obvious that such geometrical patterns have absolutely no scientific value, even when labelled "Distributive," say, or "Focusing." Neither are they of any practical utility, since the absence of some or all of the requisite numerical data renders them proof against calculation. Have they a commercial value? If so, it must be by some process which is more subtle than evident. Surely it would be better for the lighting industry as a whole if we could have information with a guarantee behind it.

The steadily increasing output of standardised glassware and the like is an achievement of which manufacturers may justly be proud, but the concurrent issue of information of an inadequate and therefore unconvincing nature is a retrograde step.

I am, Sir,
Yours, &c.,

ARTHUR BLOK.

REVIEW OF THE TECHNICAL PRESS.

ILLUMINATION AND PHOTOMETRY.

In the last few numbers of the *Science et Art de l'Eclairage* there are quite a number of articles bearing on various aspects of illumination. Prof. A. Blondel discusses signal lights. R. Houdayer contributes an historical article sketching the development in matters of **illumination in the past.** The article is illustrated by a number of pictures showing fixtures in the form of a tree, oil lamps shaped to resemble shoes, &c. J. Rougier discusses the **lighting of cinematograph theatres and underground railways.** He lays special stress on the use of appropriate reflectors in these cases, and shows that in many of the underground railways of Paris it would be possible to get greatly improved illumination from the existing lamps by this means. In such cases it is particularly essential that the artificial lighting should be good, because people have to depend entirely on artificial illumination.

H. Krüss (*Zeitschr. f. Instrumentenkunde*, Nov.) contributes an article discussing the **use of dark glasses in photometry.** He establishes relations connecting the absorption of light with the thickness of material of a given opacity, and collects the results in tabular form to show how the effect of a series of dark glass plates of a given thickness could be determined. In the course of the article he refers to early experiments in this subject, and gives some instances of the early use of glass wedges in astronomy.

J. Teichmüller (*Licht u. Lampe*, Oct. 23rd and Nov. 6th) contributes an article explaining in popular terms the chief photometric quantities (illumination, flux of light, &c.). The contribution contains a series of illustrations showing sections of the photometric solid surrounding the source and showing the nature of the polar curve in various planes.

Dr. L. Bloch (*E. T. Z.*, Nov. 13th) suggests an interesting **method of comparing the colour** of various illuminants. He proposes that a photometric comparison of the illuminants should be made, the field in the photometer being viewed in turn through green, blue, and red glasses. If, when a source is compared with daylight in this way, the ratio in the three cases is the same, we may justifiably assume that the resemblance in spectrum-composition is very close. Dr. Bloch has studied a large number of modern illuminants by this method, and collects the results in diagrammatic form in a distinctly ingenious manner. The diagram shows clearly that very few of our modern illuminants come really close to daylight.

M. Luckiesh (*Elec. World*, Oct. 25th) remarks that although much has been said on the **effect of different qualities of light radiation on the eye,** very little numerical work on this has yet been done.

He has studied the absorption of the different qualities of radiation by means of various depths of water which are considered to be equivalent to the successive regions of the eye. This is illustrated by a series of diagrams showing how each section absorbs light throughout the spectrum. It would appear that the cornea of the eye is the portion which exerts the strongest absorption effect. The *Electrical World*, in commenting on the article, remarks that we have as yet very little evidence in support of the idea that radiant energy as a whole, irrespective of its quality, has a marked effect—a "power blow"—on the eye. Injuries may be caused by ultra-violet light, but it would appear that in general the most influential factor is unsatisfactory conditions of visible light.

The last number of the *Transactions* of the American Illuminating Engineering Society contain some of the papers read at the Annual Convention to which reference was made in our last number.

The paper by F. Park Lewis on **"Psychic Values of Light, Shadow, Form, and Colour"** deserves special mention. In this the author shows how profoundly our daily life is affected by the mental impressions of surrounding objects. Therefore, the question how objects are illuminated and seen is clearly an important one, and the mind is invariably prejudicially affected by ill-lighted surroundings.

ELECTRIC LIGHTING.

Several articles have appeared dealing with **the half-watt lamp.** R. Ziegenberg (*Z. f. B.*, Nov. 10th) gives some particulars of recent developments in Berlin. It appears that they cannot as yet be made for currents of less than 4—5 amperes, and lamps from 600 to 3,000 c.p. are now becoming available. The 3,000 c.p. lamp, taking about 1,500 watts, is stated to be a very effective unit for outdoor lighting, and a photo is given of the façade of a building illuminated in this way. Polar curves of the lamps with various types of reflectors are given. One curious feature is that the resistance of these thick filaments appears to be very nearly the same when the lamps are cold as when very hot. Consequently there is no great initial rush of current.

Langmuir and Orange (*Elec. World*, Oct. 18th) also deal with this subject. Reference is made to the effect of the nitrogen in conducting heat from the filaments: it appears that the bulbs used with the new lamps reach a considerably higher temperature than that used with ordinary tungsten lamps, and in some cases it may be desirable to use specially strong glass. The intrinsic brilliancy of the new lamps is estimated at 1,200 c.p. per square inch. It is remarked that the inner side of the helical filament seems to be brighter than the outside; this is apparently due to reflected light.

Other articles by A. T. Baldwin (*Elec. World*, Oct. 18th) and Blake and Couchey (*Gen. Elec. Rev.*, July) deal with modern arc electrodes. The writer gave particulars as regards the life of various types, the effect of enclosure, and the efficiency. It would appear that the maximum efficiency obtainable is about 4 c.p. (mean spherical) per watt.

GAS, OIL, ACETYLENE LIGHTING.

There are not a great many articles in this section which require detailed comment. C. R. Bohm (*Licht u. Lampe*, Oct. 23rd) contributes a general article on **high pressure gas lighting,** and a recent number of the *Gas World* contains an account of the high-pressure lighting in the Leeds Market Hall. O. Klatte (*J. f. G.*, Nov. 1st) takes up again the vexed question of the relative costs of high-pressure gas and high-pressure air installations, and presents calculations sharing when each system has apparently the advantage. J. Rougier (*Science et Art de l'Eclairage*, Sept.) discusses modern gas lighting with inverted burners, and gives polar curves and the chief types. H. Pfotenhauer (*J. f. G.*, Nov. 1st, 15th) has a mathematical article analysing the effect of preheating on the form of the mixing chamber in an incandescent burner. The conclusion is reached that in a burner in which the mixture of gas and air is heated on its way to the mantle a conical expansion and the mixing tube leads to no good result.

Among other articles we may note that by R. Granjon (*Science et Art de l'Eclairage*, Sept.) on the **Acetylene Congress** at Rome, and an account in the *Journal für Gasbeleuchtung* (Oct. 25th) on the installation of oil-gas in a Berlin railway station.

List of References:—

Illumination and Photometry.

Bloch, Dr. L. Die Kenzeichnung der Farbe des Lichtes (*E. T. Z.*, Nov. 13).

Blondel, A. Les Aerophares (*Science et Art de l'Eclairage*, Oct.).

Editorials. The Illumination of Schools and Libraries (*Elec. Rev. and West. Electrician*, Aug. 23).

Hoeveler, J. A., and Butler, H. D. Illuminating a Drafting Room (*Elec. Rev. and West. Electrician*, Nov. 8).

Houdayer, R. L'Eclairage à travers les Siècles (*Science et Art de l'Eclairage*, Oct.).

Krüss, H. Der Rauchglaskeil als photometrische Schwächungseinrichtung (*Zeitschr. f. Instrumentenkunde*, Nov.).

Lewis, F. P. Psychic Values of Light, Shade, Form and Colour (*T. I. E. S.*, Oct.).

Luckiesh, M. Radiant Energy and the Eye (*Elec. World*, Oct. 25).

Rougier, J. Deux Problèmes d'éclairage rationnel; l'éclairage des salles de cinematographie; l'éclairage des gares souterraines (*Science et Art de l'Eclairage*, July).

Teichmüller, J. Die Photometrische Grundbegriffe für weitere Kreise erklärt (*L. u. L.*, Oct. 23, Nov. 6).

Electric Lighting.

Baldwin, A. T. Carbon and Impregnated Electrodes for Arc Lamps (*Elec. World*, Oct. 18).
Blake, S. H., and Couchey, L. H. Arcs and Electrodes (*General Electric Review*, July).
Editorial. Tungsten Lamps of high efficiency (*Elec. World*, Oct. 18).
Kraus, F. Uber die Bedingungen unter welchen ein Lichtbogen überhaupt nicht enstehen kann (*Elek. u. Masch*, Aug. 24).
Langmuir, J., and Orange, J. A. The Nitrogen filled high efficiency Tungsten Lamp (*Elec. World*, Oct. 18).
Rosenbaum, L. Die Entwicklung der elektrische Strassenbeleuchtung auf statischer Grundlage (*Elek. u. Masch.*, Nov. 2).
Zeigenberg, R. Die Halbwattlampe, ihre Entwicklung und heutige Ausführung (*Z. f. B.*, Nov. 10).

Gas, Oil, and Acetylene Lighting.

Böhm, C. R. Pressgas-beleuchtung (*L. u. L.*, Oct. 23).
Klatte, O. Wann ist die Einführung von Pressgas oder Pressluftbeleuchtung zu empfehlen? (*J. f. G.*, Nov. 1).
Granjon, R. L'Acétylène au Congrès de Rome (*Science et Art de l'Eclairage*, Sept.).
Pfotenhauer, H. Der Einfluss der Mischrohrform und der Erwärmung auf das Gasluftgemisch im Gasglüblichtbrenner (*J. f. G.*, Nov. 1, 15).
Rougier, J. L'Eclairage moderne au gaz par l'emploi de becs renversés (*Science et Art de l'Eclairage*, Sept.).
High Pressure Gas Lighting in Leeds Market Hall (*G. W.*, Nov. 15).
Why Gas Companies should Supply Lamps (*G. W.*, Nov. 15).
Die Versorgung der Berliner Bahnhöfe Mit Olgas (*J. f. G.*, Oct. 25).
The Case for Acetylene against Electricity (*Acetylene*, Oct.).

CONTRACTIONS USED.

Elek. u. Masch.—*Elektrotechnik und Maschinenbau.*
E. T. Z.—*Elektrotechnische Zeitschrift.*
J. f. G.—*Journal für Gasbeleuchtung.*
L. u. L.—*Licht und Lampe.*
T. I. E. S.—Transactions of the American Illuminating Engineering Society.
Z. f. B.—*Zeitschrift für Beleuchtungswesen.*

Cathedral Lighting by OSRAMS

A recent installation of OSRAM DRAWN WIRE LAMPS in the Choir of York Minster.

THE arrangement of the lighting is such as to give the greatest amount of illuminating power, enabling the beautiful carving of the stalls and the delicate tracery of the walls to be seen in all their beauty, and at the same time preserves them from deterioration caused by the deposits formed by other illuminants.

Write for list of REDUCED PRICES.

THE GENERAL ELECTRIC Co., Ltd.
HEAD OFFICE:
67, QUEEN VICTORIA ST., LONDON, E.C.

TRADE TOPICS.

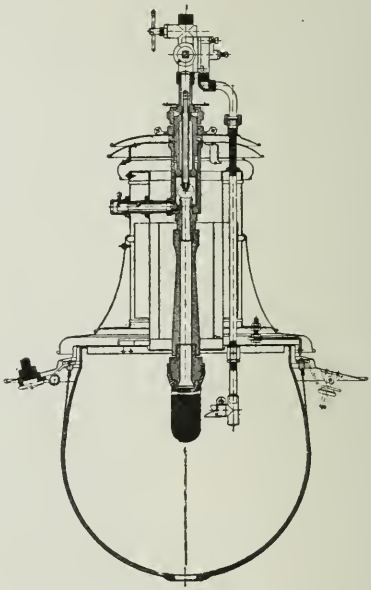
[At the request of many of our readers we have extended the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

PHAROS-WELSBACH HIGH-PRESSURE LAMPS.

In the last number of this journal it was mentioned that a series of Pharos-Welsbach lamps were used outside the National Gas Exhibition. The two illustrations below show the general appearance and details of construction of this lamp. The outstanding features are the use of a heavy cast-iron burner, with brass head carrying a nozzle composed of a special alloy, capable of withstanding the high temperature necessary in the flame of a modern high-pressure burner. This nozzle is drilled in a special manner which prevents the possibility of "lighting back," and makes it unnecessary to use gauzes.

General appearance of Pharos-Welsbach Lamp.



Sectional view, showing details.

Another point is the preheating of the primary air by passing it over a corrugated iron surface heated by the waste gases. At the same time there is no possibility of the air entering the burner being contaminated by the products of combustion. The parts of the lamp are all strong and very easily replaced, and the special form of combined auto-lighter and governed flashing bye-pass cock on these lamps enables the bye-pass to be entirely extinguished while the lamp is burning; as soon as the lamp is turned out the bye-pass is automatically rekindled.

It is stated that with gas of average quality the efficiency of the lamp is 60 c.p. per cub. ft., and the maintenance charges should be distinctly low.

The **Welsbach Light Co. Ltd.** (King's Cross, London, W.C.) issue an attractive little booklet describing these lamps, and illustrating their use for indoor and outdoor lighting.

ORNAMENTAL STREET LIGHTING.

Streetlighting with Mazdalamps in Alba glass globes on Corinthian standards. (Earl's Court Road, London.)

Admittedly there is much to be done in the design of more artistic units for streetlighting. Many of the posts in use at the present time are not exactly artistic, and in any case the glare from the powerful illuminants they support often does not encourage closer inspection.

The æsthetic aspects of streetlighting are closely allied with the elimination of glare by the subdivision of lights.

The **British Thomson Houston Co., Ltd.** (Mazda House, Upper Thames Street, London, E.C.) send us particulars of an installation on these lines outside the Brompton and Kensington Electric Restaurant in the Earl's Court Road. Each Corinthian pillar carries four arms supporting four 100-watt Mazda lamps in Alba globes, and the pillar itself terminates with a similar globe containing a 200-watt lamp. The distance from the ground to the top of the standard is 9 feet. The globes are sufficiently dense to prevent the filaments being visible and the surface appears uniformly illuminated all over. The fact of the light being thus spread over a large area gives a restful effect and soft shadows, and the Corinthian pillar is of pleasing design.

BENJAMIN STEEL REFLECTORS.

The **Benjamin Electric Ltd.** (117, Victoria Street, London, S.W.) announce that a special interior surface has been developed which will in future be applied to all Benjamin steel reflectors.

This surface is obtained by a transparent coating which forms a simple protective surface over the aluminium reflecting medium. It allows all reflectors to be cleaned easily and prevents the deterioration in efficiency which would otherwise occur. This novelty will be known as the "EZEKLEEN" reflecting surface.

SIEMENS CHRISTMAS DECORATIONS.

Messrs. Siemens Bros. Dynamo Works Ltd. (Tyssen Street, Dalston) send us a list of electrical illumination devices for Christmas, including floral decorations and lamps of many shapes and colours, for use in Christmas-tree decorations, including representations of fruit, flowers and birds: All these types are provided with clip contacts, which simplify wiring.

We have also to acknowledge the receipt of another Siemens coloured poster—this time representing an Eastern young lady admiring herself in the still water by the light of a Wotan lamp.

CROMPTON-BLONDEL OPEN TYPE FLAME ARC LAMPS.

A readable booklet issued by **Crompton & Co.** (Salisbury House, London Wall, E.C.) describes the development of the Crompton-Blondel Flame Arc Lamp. It is explained how, by the aid of special carbons, it is now possible to have a highly efficient flame arc with vertical carbons and giving a white light. Some of the illustrations show the use of such lamps for streets and factory lighting: others show special fittings (screened on the side facing the street) for outdoor shop-lighting. The booklet also contains particulars of choking coils, raising and lowering gear, &c.

MERCURY VAPOUR LAMPS IN INDUSTRIAL LIGHTING.

The **Westinghouse Cooper Hewitt Co.** (151–2, Gt. Saffron Hill, E.C.) send us a little pamphlet describing the use of mercury vapour lamps in a large number of factories (for aluminium foundries, mines, printing works, &c.). Special reference is made to the "acid proof" type of silica lamp for use in works where acid or other corroding vapours are likely to be present.

Another pamphlet from this firm refers to the use of silica lamps on power circuits; this is claimed to be the only lamp for parallel burning on 500 volts. In order to achieve this result special design has been necessary, and the lamp is a decidedly interesting novelty.

OSRAM LAMPS IN THE ARGENTINE.

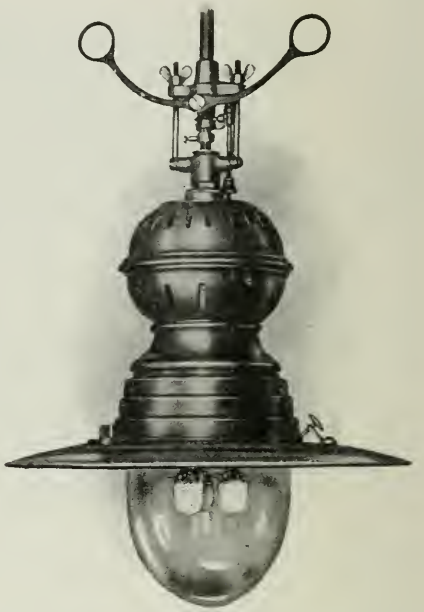
We are informed that the Anglo-Argentine General Electric Co. Ltd. have supplied a large number of Osram lamps for lighting the coaches belonging to the Anglo-Argentine Tramway Co. These are of the usual standard 100-volt type.

MAZDA HOUSE NEWS.

The November number of this little publication is fully illustrated and deals with a variety of topics. There are articles describing the lighting of shops and churches by B.T.H. methods, and a note on "Lawn Tennis after Dark." There are other chatty notes, including a two-page series of miniature reproductions of advertising blocks supplied by the company.

HELM LAMPS.

The Helm Lamp Co. (Bond Street, Nuneaton) send us particulars of their gas lamps and appliances, one of the latest forms of which is shown in the accompanying illustration. An interest-



ing point in this lamp is the patent "Switchback" attachment, which enables the gas and air adjustments to be readily made with the lamp in position.

"Electrical Services" is the title of a little bulletin issued by **Electrical Installations Ltd.** (27-28, St. Martin's Lane, E.C.). It contains a variety of information on electricity for heating, lighting and cooking, including a special section entitled "Illumination and Hygiene." It is remarked that quite one-quarter of one's life is spent under artificial light: it is therefore important to ensure that the illumination is hygienic and to attend to such matters as avoidance of glare, even light distribution, and pleasant shadow conditions.

A. P. Lundberg and Sons send us a copy of the Electric Light Certificate issued to those passing the examination, held by the firm, on Lighting Circuits—the examiner being Mr. W. Perren Maycock, M.I.E.E.

INDEX, December, 1913.

		PAGE
Correspondence (Holophane Ltd.—A. Blok)		638
Daylight Illumination, Queries on		608
Direction in Light, The Effect of	M. Luckiesh	636
Editorial		591
Factory and Industrial Lighting (L. Gaster, T. Thorne Baker, Prof. Vivian Lewes)		602
Illuminating Engineering, A Year's Progress		595
Illuminating Engineering Society—		
Account of First Meeting of Session		609
New Members		609
Report of Progress during the Vacation	L. Gaster	613
The Fourth International Congress on School Hygiene	Dr. James Kerr	616
Illumination at the National Gas Exhibition	F. W. Goodenough	611
Shadows by Natural and Artificial Light, by J. S. Dow and V. H. Mackinney		613
Motor Car Showroom, Indirect Lighting of		606
Polar Curves and Light Distribution		638
Preece, Sir William	A. P. Trotter	600
Review of Technical Press		639
Trade Notes		642

CHEAPER ELECTRIC LIGHT.

Do you realise—

That the Mazda drawn wire process has conquered fragility and banished uncertainty of performance.

That there have been more improvements in Mazda Lamps in two years than during 20 years with carbon lamps.

That more than 50 technical experts with as many more highly trained assistants are continually working in a number of research laboratories to make Mazda Electric Lamps better and cheaper.

That it is this body of scientific workers that has evolved practically all the important lamp improvements of the past few years.

That the drawn wire process was their development, and that this improvement was first introduced and employed in the Mazda Lamp.

That with improvements in mechanical construction the strength and durability of the Mazda Drawn Wire Lamp have been greatly increased.

That Mazda Lamps embody radical improvements in methods of exhausting which eliminate blackening.

That the efficiency of Mazda Lamps for the same life and candle-power performance has been markedly advanced.

That the Mazda drawn wire process permits lamps to be more accurately made.

That Mazda Drawn Wire Lamps are extensively used in the home and for street lighting, and in large factories, mills, and shops.

That they are vibration proof.

That over thirty million Mazda Drawn Wire Lamps are in use to-day.

That this fact is the finest testimony to their good qualities and the satisfaction they give

That some fifteen up-to-date lamp works in different parts of the world are busy making Mazda Drawn Wire Lamps to supply the world's demands.

That the combined output of these works is now over a million Mazda Drawn Wire Lamps per week.

That they will all be wanted—the demand exceeding the supply.

That all Mazdas for the English market are made in Rugby.

That an interesting publication "Lighting News" will be sent free on request from Mazda House, 77, Upper Thames Street, E.C.

That by the exclusive use of Mazda Drawn Wire Electric Lamps you ensure maximum economy.

That Mazda Lamps are obtainable at new and reduced prices from Electrical Contractors, Ironmongers, and Stores.

[ADVT.

THE

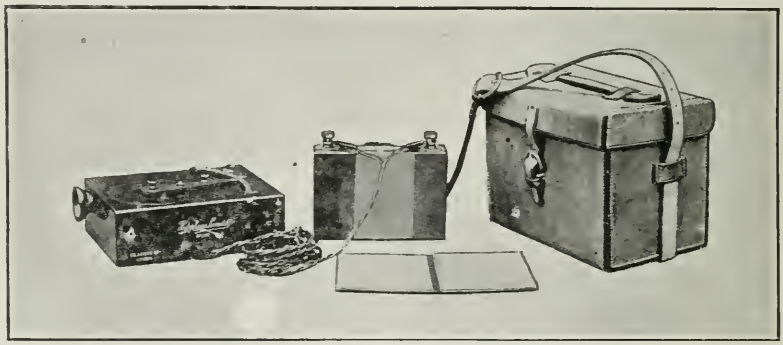
Holophane Lumeter.

THE simple, portable, and accurate apparatus for measuring illumination, surface-brightness, or reflecting power.

Can be carried from place to place with the ease of a small hand camera.

Dimensions only $5\frac{3}{4}$ in. × $4\frac{1}{2}$ in. × $1\frac{3}{4}$ in.; case and accumulators supplied.

Measurements from 0·01 to 2000 foot-candles can be made.



Showing general appearance of new model of Holophane Lumeter.
(Dimensions: $5\frac{3}{4}$ in. × $4\frac{1}{2}$ in. × $1\frac{3}{4}$ in.)

The Holophane Lumeter is of value not only to lighting engineers, but to architects, medical officers, factory inspectors, photographers, and many others.

Among the users of this instrument may be mentioned:—

The House of Commons, The Home Office (Factory Dept.), The London County Council, General Post Office, Great Western Railway, L. & S.W. Railway, Underground Railways, The Gas Light & Coke Co., St. James and Pall Mall Electric Supply Co., The Union Electric Co., The British Thomson-Houston Co., &c., &c.

For all particulars apply to

HOLOPHANE, LTD.,

12, Carteret St., Queen Anne's Gate, S.W.

TP
700
L54
v.6

Light and lighting

~~Physical & Applied Sci. Serials~~

Engineering

PLEASE DO NOT REMOVE
CARDS OR SLIPS FROM THIS POCKET

UNIVERSITY OF TORONTO LIBRARY

ENGIN STORAGE